

# HERPETOFAUNA

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Amplexing *Litoria peronii* from Smith's Lake, NSW (Photo: J. Rowley). See paper on male combat in this species on p. 42.

Herpetofauna was formerly published by the Australasian Affiliation of Herpetological Societies, which has been dormant for a number of years. This final issue is published by the AAHS and the Australian Herpetological Society, one of the members of the AAHS and the society that commenced the journal in 1963. The AAHS has now been dissolved.

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## EDITORIAL

*Herpetofauna* commenced in 1963 as a publication of the Australian Herpetological Society, based in Sydney. From Volume 7, in 1974, it was published by an informal alliance of five societies in NSW, SA, Victoria and Queensland to create an expanded subscriber base. From 1977, to facilitate communication among the amateur and professional herpetological communities, the four remaining societies formalised their affiliation as the Australasian Affiliation of Herpetological Societies, later adding many newly established societies throughout Australia and New Zealand under a single banner. In the 61 years of its existence, 84 issues of *Herpetofauna*, spread over 45 volumes, and containing over a thousand papers, have been produced. This volume, however, will be the last in its current format.

Many of the member societies of the Affiliation have over recent decades pivoted in their own membership towards a herpetocultural base, and *Herpetofauna*, which has long emphasised the publication of original field observations, has gradually become of less relevance and interest to that base. The authors of papers published in the journal have continued to include members of the Affiliation's member societies, but the majority of authors and readers are now professional herpetologists and wildlife managers external to the Affiliation. Further, with the rise of the internet and social media, the need for an umbrella organisation to develop links between herpetologists throughout the Australasian region is less critical. The COVID years exacerbated this trend, and as a result, the decision has been made by the member societies to disband the Affiliation.

The publishing rights to *Herpetofauna* will now return to the founder of the journal, the Australian Herpetological Society, under the Affiliation's constitution.

It is my strong belief that *Herpetofauna* has been, and should continue to be, an important vehicle for publication of knowledge

about the Australasian herpetofauna. While there are other journals published by the field naturalist societies in various Australian states in which herpetological field observations can be published, no such society has existed in NSW for many decades. Further, the field naturalist journals cater to a much broader range of topics than herpetology. *Herpetofauna* has long had the advantage of being purely herpetological, providing a first port-of-call for those seeking papers on reptiles and amphibians in the region.

While there are international herpetological journals that also publish field observations by Australian authors, many of these have an author-pay model of publication, a model that can dissuade authors lacking institutional funding.

While there are now online aggregators of locality data such as iNaturalist and the Atlas of Living Australia to provide real-time availability of distributional data, along with a plethora of social media pages on which field photographs of interesting observations such as reproductive behaviour, predation records and other interactions are posted daily, there is still a need for publications to combine a validated record with the significance of that record in light of the existing literature, a role that *Herpetofauna* has played since its inception. This final issue exemplifies the diversity that has characterised *Herpetofauna*, with papers on male combat, diet, predation, parasitism, range extensions, faunal survey, ontogenetic change and habitat preferences, as well as husbandry.

*Herpetofauna* has long encouraged first-time authors, and as editor, I have devoted much time to assisting new authors with their manuscripts to bring them to a suitable scientific standard. However, in recent years, exacerbated by an increase in the workload of my paid employment, I have been unable to devote as much time as I would like to working on submitted manuscripts, and I have made the decision to step down as editor of the journal. At this point in time, while several people have offered to become

members of an expanded scientific editorial board of the journal, there is still a need for an experienced herpetologist to chair that board, and the Society is still seeking someone to fill that role. In order for *Herpetofauna* to continue to be of interest as a vehicle for publication of scientifically reputable papers (and to attract submissions from the professional community as well as the amateur community, maintaining its role as a bridge between the communities), I consider it essential that the editor-in-chief be a scientist and that manuscripts be independently reviewed by scientists.

In the meantime, *Herpetofauna* will be taking an indefinite hiatus from publication. If it is to continue, it is likely to return as an online publication, bringing it in line with modern scientific publications. This allows for papers to be more rapidly published if accepted after

review and revision, without the need to wait for sufficient papers to accumulate to produce a composite issue. It is also cheaper to run an online system than to produce hard copy issues, and an online archive is more accessible in the digital age than hard copy journals. In the meantime, the Australian Herpetological Society will shortly be providing an open-access digital archive of all issues of *Herpetofauna* through its website, [www.ahs.org.au](http://www.ahs.org.au).

In bowing out, I would like to thank the many authors who have entrusted me with their manuscripts, and the numerous manuscript reviewers (two per manuscript), without whom there would not have been any journal.

Glenn Shea,  
Editor 2001-2014,  
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# CONFIRMATION OF THE THREE-LINED SKINK *ACRITOSCINCUS DUPPERREYI* IN MORTON NATIONAL PARK

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## INTRODUCTION

The Three-lined Skink *Acritoscincus duperreyi* has a distribution associated with cool temperate forests, woodlands and heaths in Tasmania, south-east of South Australia, Victoria and eastern New South Wales (NSW) as far north as the Newnes plateau (Wilson & Swan, 2013). Jenkins (1987) states that this species (as *Leiolopisma trilineata*) exists in Morton National Park (NP) on the south coast of NSW. A review of the Atlas of Living Australia (ALA 2014) reveals one specimen observed

east of Morton NP. There are no voucher specimens or photographic images to verify the previous records. The absence of such records and the fact that the species can be readily confused with species of *Pseudemoia* has prompted this note.

On 30 October 2007 an *A. duperreyi* was observed within Morton NP about ten kilometres west of Sassafras NSW (35°04'S, 150°12'E). The lizard was in woodland that had a dense shrublayer of sedges and heathland species at an altitude of 770 m AHD

**Figure 1. Three-lined Skink *Acritoscincus duperreyi* from Morton NP (Photo by G. Daly, 30 October 2007).**



(Figure 1). The image shows the fused frontoparietal scales as opposed to paired frontoparietals in *Pseudemoia*.

*Acritoscincus duperreyi* occurs in this region as small fragmented populations along the higher parts of the escarpments. Previous surveys in Morton NP (Daly, 2006) failed to detect this species indicating that it has a restricted distribution. The species has also been detected in Barren Grounds Nature Reserve (N. Jackett and J. Hinde, pers. comm.) and the upland swamps of the Woronora, O'Hares and metropolitan special area north of Wollongong (DECC, 2007). In the Illawarra/Morton NP area the species is closely associated with dense vegetation on upland swamps perched on Hawkesbury and Nowra sandstones.

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**PREDATION OF A COMMON RINGTAIL POSSUM  
(*PSEUDOCHEIRUS PEREGRINUS* BODDAERT, 1785) BY AN  
EASTERN WATER DRAGON (*INTELLAGAMA LESUEURII* GRAY, 1831)**

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## INTRODUCTION

The Eastern Water Dragon (*Intellagama lesueurii*) is the largest agamid species in Australia (SVL = up to 245 mm, mass = up to 1000 g), and has a distribution ranging along the east coast from Cooktown, Qld, to Gippsland, Vic (Thompson, 1993; Wilson & Swan, 2013). Commonly kept as pets, this species consumes a variety of food items in captivity, including fish, fruit, insects, processed pet foods, rodents, snails, vegetables and yabbies (Hosking, 2010). In the wild, these lizards ontogenetically shift from being primarily insectivorous as juveniles to an omnivorous diet as adults (Hosking, 2010). Previously documented prey items include crustaceans, Delicate Skinks (*Lampropholis delicata*), juvenile conspecifics, Mosquitofish (*Gambusia* sp.), molluscs, Eastern Water Skinks (*Eulamprus quoyii*), and a variety of insects and scorpions (Anonymous, 1976; Greer, 1990; Wilson & Knowles, 1992; Meeks et al., 2001; Baxter-Gilbert, 2014; Frère et al. 2015). Other food items include algae, bird faeces, flowers, figs, lillypillies and other fruits (Mackay, 1959; Clifford & Hamley, 1982; Greer, 1990; Ehmann, 1992; Baxter-Gilbert, 2014). Here, we report a novel prey item, based on an observation of a single wild-living lizard residing within the greenspace of the Taronga Zoo grounds in Sydney, New South Wales.

## OBSERVATION

On 18 November 2016 at 0745 hrs AEDT we observed an adult male Eastern Water Dragon (SVL = 220 mm; Figure 1) carrying a deceased juvenile Common Ringtail Possum (*Pseudocheirus peregrinus*) in its mouth across the children's playground at Taronga Zoo, Sydney, NSW. The skull of the possum was noticeably crushed. During the next 20

minutes we made efforts to photograph and measure the lizard, resulting in it fleeing across the playground, through a waterfowl exhibit, and swimming across a small pond (Figure 2). Although we were unable to directly observe the lizard consuming the prey item, at no point during our investigation of this event did the lizard exhibit any sign of releasing or leaving the possum during our pursuit; suggesting it did intend to consume it.

## DISCUSSION

Unfortunately, we were unable to see the initial events that brought the juvenile possum and the dragon together in the first place. Perhaps the young possum fell out of its drey and the dragon came across it while foraging in the leaf litter. However, Eastern Water Dragons have been seen to forage arboreally for tree-dwelling insects (e.g., cicadas; Anonymous 1976), and, as such, the dragon may accidentally have come upon the possum up a tree. Alternatively this may have been an active hunt, with the dragon ascending into a tree with the intent to capture and consume a young possum. Without further investigation of Eastern Water Dragon hunting and foraging strategies, we will never know.

We would assert that the crushed skull of the possum was a result of the dragon, rather than by other means, such as a collision with a vehicle or human persecution. The average bite force of an adult male Eastern Water Dragons in the greater Sydney area is  $317.9 \text{ N} \pm 18.0 \text{ N}$  (Baxter-Gilbert & Whiting, 2019). Using a freshly deceased juvenile possum (acquired from a local veterinary office) and a hydraulic piston exerting a known force over a  $6.45 \text{ cm}^2$  pad we determined the pressure required to buckle an intact juveniles possum skull is only  $111.8 \text{ N}$ ;



**Figure 1. An adult male Eastern Water Dragon observed carrying a juvenile Common Ring-tail Possum.**



**Figure 2. Emerging from a pond after 20 minutes of evading capture (i.e., the author attempting to measure the lizard's SVL) the Eastern Water Dragon still refuses to release the juvenile Common Ring-tail Possum.**





well below the potential bite force of adult male water dragons. Thus, it is completely within the physiological capabilities of adult male Eastern Water Dragons to crush the skull of juvenile possums.

Overall, it is clear from previously published reports that the diet of Eastern Water Dragons is highly variable, and this observation adds another species to the list of known prey items. Notably, this is the largest vertebrate prey item ever recorded for this species. The curiosity of this observation is how the dragon found the possum, and whether the possum was actively sought out or if it was mere coincidence the dragon came across it. Since making this observation, one of the authors (JBG) has noted several pictures and a short video, on social media platforms, of Eastern Water Dragons consuming another juvenile possum and a young flying fox, however these two observations were never formally documented. Nevertheless, these accounts suggest the hunting of young mammals by Eastern Water Dragons may be more common than expected. It is our hope that this natural history observation will spur further examinations of urban Eastern Water Dragon foraging strategies, diets, and their role in anthropogenically-modified food webs.

## ACKNOWLEDGMENTS

We would like to thank Dr Martin Whiting and Dr Glenn Shea for their insights into Water Dragon and their diets. This observation was made during field research on urban populations Eastern Water Dragons, and handling of the lizard was in accordance with Macquarie University Animal Ethics Committee (AEC Ref. No.: 2015/023-4) and under a scientific licence (SL100570) from New South Wales National Parks and Wildlife Service.

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**OBSERVED POISONING AND RECOVERY OF A CARPET PYTHON,  
*MORELIA SPILOTA* (SERPENTES: PYTHONIDAE), FOLLOWING THE  
ATTEMPTED INGESTION OF AN ADULT CANE TOAD,  
*RHINELLA MARINA* (AMPHIBIA: BUFONIDAE)**

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**ABSTRACT**

Invasive vertebrates, such as the toxic Cane Toad (*Rhinella marina*), present a significant threat to biodiversity conservation in Australia. Cane Toads are a highly toxic bufonid of South American origin to which native predators are physiologically and behaviourally naive. Large reptiles, such as pythons, that mistake toads as native frogs risk fatal poisoning from ingesting toads. Here, we present an observation of a Carpet Python (*Morelia spilota*) following an attempted ingestion of a single *R. marina*, with notes on treatment and recovery. Fluid therapy is the favoured treatment for toad poisoning by wildlife carers. Although *M. spilota* are highly sensitive to cane toad toxin, they favour mammalian prey and their vulnerability to fatal ingestion of toads has not been found to result in population level ecological impacts.

**INTRODUCTION**

Since their introduction to northeast Queensland in 1935, Cane Toads (*Rhinella marina*) have presented a significant conservation challenge (reviewed in Shine, 2010). Although many direct and indirect impacts of toads on native fauna have been identified (Shine, 2010), the most obvious and significant of these has been to large frog-eating predators via fatal toxic ingestion (Covacevich & Archer, 1975; Shine, 2010; Evans *et al.*, 2011). Aside from a few colubrid snakes, such as the Keelback (*Tropidonophis mairii*), a species with a recent evolutionary history of successful bufophagy, few Australian snakes can successfully consume *R. marina* (Phillips

*et al.*, 2003; Phillips & Shine, 2004; Llewelyn *et al.*, 2009). Despite this, even *T. mairii* suffer impaired motor function, poor body condition and occasionally mortality after consuming Cane Toads (Ingram & Covacevich, 1990; Llewelyn *et al.*, 2009). Since Australian snakes typically ingest their prey whole and anurophagy is common, 30% of Australian snakes were considered vulnerable to toad caused population-level impacts (Phillips *et al.*, 2003; Phillips & Shine, 2006a; Shine, 2010). Habitat overlap, gape size, poor ability to learn taste aversion, anurophagy and physiological sensitivity to bufadienolides increase a species' vulnerability to *R. marina* (Phillips *et al.*, 2003; Shine, 2010). Some taxa possessing these characteristics, for instance monitor lizards, suffer significant ecological impacts (Brown *et al.*, 2011; Doody *et al.*, 2015; Jolly *et al.*, 2016). Feeding trials with wild caught snakes show many species will succumb to *R. marina* while others show variable avoidance or tolerance (Phillips *et al.*, 2003; Pearson *et al.*, 2014), however, predictions from these trials rarely correspond to field observations (Shine, 2010; Brown *et al.*, 2011, 2013). In fact, the impact of *R. marina* on snake populations has been less substantial than predicted, though poisonings are expected (Shine, 2010; Brown *et al.*, 2013; Pearson *et al.*, 2014).

Given the inherent difficulty in correctly diagnosing bufotoxin symptoms *in situ*, few field observations for toad poisoning exist. Besides detailed records on *T. mairii* (Phillips *et al.*, 2003; Llewelyn *et al.*, 2009; Shine, 2010) and the Floodplains Death Adder (*Acanthophis hawkei*; Hagman *et al.*, 2009; Phillips



et al., 2010; Brown et al., 2011), most studies focus on captive feeding trials, adaptive shifts in prey selection, morphology or physiology (Phillips & Shine, 2004, 2006a; Pearson et al., 2014). Cases of recorded ingestion are rare, including one road-killed Carpet Python (*Morelia spilota*; Covacevich & Couper, 1992), two Coastal Taipans (*Oxyuranus scutellatus*; Chatto & Trembath, 2012; C. Jolly, pers. obs.), and three reported feeding attempts by Eastern Brown Snakes (*Pseudonaja textilis*; Phillips & Fitzgerald, 2004). Here, we present an observation of a wild *M. spilota* following attempted consumption of a toad, with a summary of our notes and rehabilitation records.

## OBSERVATIONS

At 1130 hours on 25 February 2015, JT was alerted to "an injured snake" by property maintenance contractors near Gold Creek Reservoir in Brisbane, Queensland. Upon inspection, an adult Carpet Python (*M. spilota*; approx. 1.5 m total length) was discovered next to a deceased adult Cane Toad (*R. marina*; Fig. 1A). The lower dorsal surface of the toad exhibited multiple small punctures. The rear legs were folded forward over the head of the toad (Fig. 1B). Near the snake's cloaca we found multiple solid urate balls and significant amounts of moisture with no dark faecal matter (Fig. 1C). The snake appeared dehydrated, with loose folds of skin running laterally down the body. It was unresponsive and was unable to support its body-weight or move its head steadily. Breathing was slowed to approximately one breath per minute.

Fluid therapy was promptly commenced, delivering a total 30 ml of saline (0.9%) subcutaneously, in three equal boluses along the left dorso-lateral, mid-body region, about 5–10 cm apart (within the upper range of maintenance fluid requirements for reptiles: 10 to 30 ml/kg/d; Music & Strunk, 2016). Veterinarians recommended observation, and in the event of no improvement within 12 hours, further fluid therapy with optional intra-

coelomic injections into the caudal abdomen (13 ml saline every 24 hours, J. Llinas, pers. comm.). JT maintained the snake in captivity for continued monitoring (under DEHP permit WIRP13290813). No further intervention was required. The following day the snake showed noticeable improvements in mobility and after three days was seen drinking ~200 ml of water unassisted. Feeding and unobstructed bowel movement were followed by successful release on 14 March 2016 (details in Table 1).

## DISCUSSION

From the tooth-puncture alignment and posture of the prey item (Fig. 1A–B) it appears the snake attempted to swallow the prey backwards. This suggests the toad's parotoid glands were outside the snake's buccal cavity, as opposed to the typical method used by snakes of swallowing prey head first (Loop & Bailey, 1972; Phillips & Shine, 2006b). The apparent loss of motor performance is consistent with poisoning from *R. marina* (Phillips et al., 2003; Phillips & Fitzgerald, 2004; Phillips & Shine, 2006a). Rapid loss of waste products (Fig. 1C) and subsequent dehydration are possibly in response to ingested bufotoxins (Mayer & Donnelly, 2013). Alternatively, the poor condition of this snake may have been present before the attempted predation and could have been a factor motivating this snake to consume a potentially fatal prey species.

Fluid therapy can be integral in re-establishing homeostasis in the event of poisoning. Although isotonic replacement fluids via vascular access are a more efficient means of fluid administration and resuscitation, it is only practical in the most moribund snakes and in this case was not feasible. While our treatment may have been beneficial, it is unlikely the sole cause of the observed rapid recovery (Rüdloff, 2005; Music & Strunk, 2016; J. Llinas, pers. comm.). It is much more likely that the position of the toad as it was being consumed allowed this snake to receive a sub-lethal oral dose, which deterred it from

**Figure 1. Carpet Python, *Morelia spilota*, next to prey item, *Rhinella marina*. (A) In situ as found. (B) Deceased prey item, *Rhinella marina*. (C) Urate waste from *M. spilota*.**



consuming the whole toad and prevented fatal poisoning (Pearson *et al.*, 2014).

Various factors apparently mitigate toad-cause population-level impacts to native snakes (Brown *et al.*, 2013). These include rapid selection for smaller gape-to-body ratio, variation in physiological tolerance to bufadienolides, including bufotoxin, and behavioural adaptations such as selective prey avoidance (Phillips & Shine, 2006b; Shine, 2010; Pearson *et al.*, 2014). *Rhinella marina* can also have an indirectly positive impact on native fauna. Australian monitor lizards, which depredate both snakes and anurans, incur heavy population declines in response to *R. marina* invasions, lowering predation pressure on smaller toad-vulnerable predators (Brown *et al.*, 2011; Doody *et al.*, 2015; Jolly *et al.*, 2015, 2016). This 'mesopredator release' potentially allows snake populations to increase, despite mortalities directly attributed to *R. marina* (Phillips *et al.*, 2010; Shine, 2010; Doody *et al.*, 2015).

With their ability to consume relatively large prey, nocturnal hunting behaviour and occasional anurophagy, certain python species appear vulnerable to toad poisoning (Phillips *et al.*, 2003; Phillips & Shine, 2004; Pearson *et al.*, 2014). *Morelia spilota* and the *Antaresia* genus appear somewhat vulnerable, with low tolerance and recorded mortalities in feeding trials (Brown *et al.*, 2011; Pearson *et al.*, 2014). *Antaresia childreni* consumed 22% of offered toads with a 66.6% mortality rate, while *M. spilota* consumed 80% of offered toads with 100% mortality. Despite their typically non-anuran diet (Fearn *et al.*, 2001), there are occasional mortalities of *M. spilota* from ingesting toads with anecdotal observations not uncommon (Covacevich & Couper, 1992; Brown *et al.*, 2011; Pearson *et al.*, 2014; J. Torkkola, pers. obs.). Some populations show long-term declines, though caution is recommended in attributing trends to toads over factors such as road proximity, climate and prey abundance (Brown *et al.*, 2011, 2013). Nevertheless most python species appear to suffer relatively few losses



Table 1. JT Wildlife Rehabilitation Records for Carpet Python #007, *Morelia spilota*.

Date rescued	Reason for rescue	Species	Location	Sex	Age Class	Health/injuries
25/02/15	Adult with cane toad toxicity after attempted ingestion of <i>Rhinella marina</i> .	<i>Morelia spilota</i>	Gold Creek Reservoir, Brookfield, QLD	M	adult ~1.5m	Found next to half consumed, regurgitated cane toad. Severely dehydrated, evidence of lots of fluid loss from cloaca. Very limp, little reaction to touch or handling, but alert enough to move its head.

Treatments	Observations	Regular weights
Seen by Local Vet Surgery, 25/02/15 30 mL of saline subcutaneously In for observation and potential for further fluid therapy if no improvement	25/02/15 - Very lethargic, however has coiled on top of heat mat in hide	1.3 kg 25/02/15
	26/02/15 - Slightly more active and alert, no need for further fluid therapy	
	28/02/15 - Observed large drinking event! Approx. 200 ml	
	01/03/15 - Climbed up to basking position, much better control - Start feeding (medium rat)	1.35 kg 01/03/15
	13/03/15 - Bowel movement, slightly runny, otherwise ok, uric ball semi-solid	
	14/03/15 - Release!	1.5 kg 14/03/15

in response to Cane Toads, which have not been found to equate to population-level impacts. Recently, when Carpet Python populations in northern New South Wales were compared between multiple adjacent sites with and without Cane Toads there was found to be no difference in the abundance of this species (Jolly *et al.*, 2015).

While some reptile species seem to adapt via morphological shifts to smaller head size, the preponderance of large prey items in the diet of *M. spilota* suggests such morphological shifts are unlikely (Loop & Bailey, 1972; Fearn *et al.*, 2001; Phillips & Shine, 2004). Nonetheless, *M. spilota* seems unlikely to suffer significant impacts from cane toads due to their preference for mammalian prey and potential for physiological or behavioural plasticity (Fearn *et al.*, 2001; Phillips *et al.*, 2010; Pearson *et al.*, 2014).

Fluid therapy appears to be a favourable treatment option for veterinarians and wildlife carers confronting bufotoxin ingestion in *M. spilota*. We suggest that it continue to be used when toad-poisoning cases are suspected, particularly when subjects experience dehydration.

## ACKNOWLEDGMENTS

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# A NEW DIETARY RECORD FOR THE EASTERN WATER SKINK, *EULAMPRUS QUOYII* (DUMÉRIL & BIBRON, 1839)

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## INTRODUCTION

The Eastern Water Skink *Eulamprus quoyii* is a robust, semi-aquatic sphenomorphine skink which occurs along the east coast of Australia from Cairns south to south-east New South Wales and inland to South Australia along the Darling-Murray drainage (Wilson & Swan, 2013). Throughout its range it is commonly associated with, but not restricted to, riparian habitats associated with waterways.

The diet of the species has been studied by Veron (1969) who sampled the stomach contents of 59 specimens shot or captured from February to April 1967 in the Armidale area of NSW, and Daniels (1987) who reported stomach contents of a further 50 specimens from the same area between January and March 1982. Their work showed *E. quoyii*

consumes a wide range of flying, terrestrial, aquatic and burrowing invertebrates of varying sizes, including molluscs, insects and spiders. The invertebrate prey items recorded that were associated with an "aquatic" environment were damselfly larvae (Odonata), mayfly larvae (Ephemeroptera), stonefly larvae (Plecoptera), aquatic beetles (Coleoptera) and bugs (Hemiptera), a freshwater shrimp and three Crustacea not identified beyond the class level. Additional observations have been made of *E. quoyii* feeding on tadpoles and metamorph frogs (Pyke & Miehs, 2001) and floating frog spawn (Robinson, 2004), while Annable and Metcalfe (2015) reported adults eating small skinks, including conspecifics, and snails and slugs. However, there are no literature records of *E. quoyii* eating crayfish.

**Figure 1. Adult *Eulamprus quoyii* attempting to swallow a small freshwater crayfish.**





## OBSERVATIONS

On 11 September 2014 on the bank of the Macintyre River at Inverell (29°46'31"S 151°06'35"E), an adult *Eulamprus quoyii* was observed by the author with a small freshwater crayfish in its mouth (Figure 1). The crayfish appeared to be a Yabby (*Cherax destructor*, Parastacidae) estimated to be approximately 40 mm in total length, which the skink was attempting to swallow. The lizard was not observed catching the crayfish, nor was the crayfish observed to move, but it appeared to be a fresh kill. A Rakali (*Hydromys chrysogaster*) was observed in the same stretch of water, but it is unlikely that the crayfish was scavenged from a Rakali kill as the chelipeds were still attached even though the tail of the crayfish was missing. Rakalis usually remove the chelipeds from crayfish before eating (pers. obs.). Veron concluded that "there is no evidence that *S. quoyii* feed under water". However, the presence of damselfly larvae, mayfly larvae, stonefly larvae and a freshwater shrimp in his study do not conclusively support this assertion (see Zborowski & Storey, 2010, for details of the biology of the insect larvae). Daniels (1987) concluded that aquatic food items were mostly eaten when they approached the surface, an argument also made by Pyke and Miehs (2001). Veron (1969) also reported crickets being part of the diet of *E. quoyii*. It is possible that the crickets were taken from burrows, so it is also possible that the crayfish was caught in a burrow, rather than in the water.

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# PREDATION OF DIAMOND PYTHON (*MORELIA SPILOTA*) BY RED FOX (*VULPES VULPES*)

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## INTRODUCTION

The Red Fox *Vulpes vulpes* was released directly into the wild at least five occasions between 1845 and 1873 (Abbott, 2011), and now occupies most of continental Australia except for portions of the tropics (Robley *et al.*, 2004). Red Fox reached the Shoalhaven area of south-eastern New South Wales (NSW) in 1907 (Elliott, 1942). Predation by the Red Fox is listed as a key threatening process under the NSW Biodiversity Conservation Act (2016) and the Environmental Pro-

tection and Biodiversity Conservation Act (1999). The NSW Threat Abatement Plan (OEH, 2011) states that eradication of Red Fox on mainland Australia is not possible.

The impact of Red Fox on native fauna has been well documented for a broad suite of mammals (OEH, 2011) and ground nesting birds (Smith *et al.*, 1994). Mammals within the 'so called' critical weight range (Burbidge & McKenzie, 1989) are most affected. A list of herpetofauna species listed Nationally as threatened that may be preyed by Red Fox is given in Table 1 (DEWHA, 2008).

**Table 1. Species of herpetofauna listed under the DEWHA (2008) threat abatement plan subject to predation by the Red Fox.**

Scientific Name	Common Name	Reference
<i>Caretta caretta</i>	Loggerhead Turtle	Limpus & Reimer 1994
<i>Chelonia mydas</i>	Green Turtle	Environment Australia 2003
<i>Dermochelys coriacea</i>	Leatherback Turtle	Environment Australia 2003
<i>Elusor macrurus</i>	Mary River Turtle	Flakus 2002
<i>Emydura macquarii signata</i>	Bellinger River Emydura	NSW Scientific Committee 2008; Blamires <i>et al.</i> 2005
<i>Natator depressus</i>	Flatback Turtle	Environment Australia 2003
<i>Pseudemydura umbrina</i>	Western Swamp Turtle	(Little direct evidence) Burbidge 1967; Burbidge & Kuchling 2004
<i>Rheodytes leukops</i>	Fitzroy Turtle	Limpus 2007
<i>Delma impar</i>	Striped Legless Lizard	(Anecdotal evidence) DEWHA 2008
<i>Eulamprus tympanum marnieae</i>	Corangamite Water Skink	(Suggested threat) Robertson 1998
<i>Liopholis kintorei</i>	Great Desert Skink	Environment Australia 2003
<i>Hoplocephalus bungaroides</i>	Broad-headed Snake	(Suggested threat) DE 2014a
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	(Suggested threat) DE 2014b
<i>Litoria aurea</i>	Green and Golden Bell Frog	DEC 2005



**Figure 1. Diamond Python that a Red Fox was eating at Bundanon, NSW.**



Published accounts of predation of herpetofauna by Red Fox are mainly the eggs/hatchlings of turtles (Blamires *et al.*, 2005; Flakus, 2002; Limpus, 2007; Limpus. & Reimer, 1994; NSW Scientific Committee, 2008). However, Red Fox eat a wide range of reptiles and frogs (Table 2). Studies on the impacts of Red Fox predation on lizards indicate a complex interaction with top order predators (Olsson *et al.*, 2005; Robley *et al.*, 2004).

We provide photographic evidence of predation of the Diamond Python *Morelia spilota spilota* by the Red Fox. On 3 January 2015 a fox was shot at Bundanon on the south coast of New South Wales. Prior to shooting the fox was observed to be eating an animal. Once shot it was found that the fox was consuming a Diamond Python (Figure 1). The senior author has located two partially eaten bodies of Diamond Pythons near Bundanon (one of which is shown in Figure 2) that may also have been eaten by Red Fox.

The Victorian Museum states that Inland Carpet Pythons *Morelia spilota metcalfei* are preyed upon by foxes (<http://museumvictoria.com.au/melbournmuseum/discoverycentre/wild/victorian-environments/mallee/inland-carpet-python/>) while in contrast there has been one report of a Coastal Carpet Python *Morelia spilota mcdowelli* killing a Red Fox (Mmackander, 2012).

Red Fox require about 500 grams of food each day (Sillero-Zubiri *et al.*, 2004). The wide range of small reptiles and frogs eaten indicates that this carnivore is opportunistic in the prey taken. Many small reptiles or frogs would have to be eaten to constitute the daily

**Figure 2. Partially eaten Diamond Python located at Tapitallee, NSW.**



**Table 2. Species of herpetofauna subject to predation by the Red Fox.**

Scientific Name	Common Name	Reference
<i>Chelodina expansa</i>	Broad-shelled Turtle	Spencer & Thompson 2005
<i>Chelodina longicollis</i>	Long-necked Turtle	Molsher 1999
<i>Emydura macquarii</i>	Murray River Turtle	Spencer & Thompson 2005
<i>Diplodactylus tessellatus</i>	Tessellated Gecko	Palmer 1995
<i>Gehyra versicolor</i>	Tree Dtella	Catling 1988; Palmer 1995
<i>Lucasium damaeum</i>	Beaded Gecko	Catling 1988; Molsher 1999
<i>Oedura cincta</i>	Marbled Velvet Gecko	Catling 1988
<i>Rhynchoedura ormsbyi</i>	Beaked Gecko	Catling 1988; Molsher 1999
<i>Strophurus intermedius</i>	Southern Spiny-tailed Gecko	Catling 1988
<i>Underwoodisaurus milii</i>	Thick-tailed Gecko	Catling 1988; Molsher 1999
<i>Pygopus nigriceps</i>	Black-headed Scaly-foot	Catling 1988; Molsher 1999
<i>Pogona barbata</i>	Eastern Bearded Dragon	Lugton 1993; Martensz 1971
<i>Pogona vitticeps</i>	Central Bearded Dragon	Catling 1988; Palmer 1995
<i>Varanus gouldii</i>	Sand Goanna	Catling 1988; Martensz 1971
<i>Anomalopus leuckartii</i>	Two-clawed Worm Skink	Molsher 1999
<i>Ctenotus robustus</i>	Striped Skink	Molsher 1999
<i>Egernia striolata</i>	Tree Skink	Molsher 1999
<i>Eulamprus tympanum</i>	Southern Water Skink	Green & Osborne 1981
<i>Lerista timida</i>	Three-toed Lerista	Catling 1988
<i>Lerista punctatovittata</i>	Spotted Lerista	Catling 1988
<i>Liopholis whitii</i>	White's Skink	Green & Osborne 1981
<i>Morethia boulengeri</i>	Boulenger's Morethia	Palmer 1995
<i>Pseudemoia entrecasteauxii</i>	Tussock Skink	Green & Osborne 1981
<i>Tiliqua rugosa</i>	Shingleback Lizard	Lugton 1993; Martensz 1971
<i>Anilius bituberculatus</i>	Prong-snouted Blind Snake	Catling 1988
<i>Anilius proximus</i>	Woodland Blind Snake	Molsher 1999; Martensz 1971
<i>Brachyuropsis australis</i>	Australian Coral Snake	Catling 1988
<i>Pseudechis australis</i>	Mulga Snake	Palmer 1995
<i>Suta spectabilis</i>	Mallee Black-headed Snake	Catling 1988
<i>Suta suta</i>	Curl Snake	Molsher 1999
<i>Limnodynastes interioris</i>	Giant Banjo Frog	Catling 1988
<i>Limnodynastes fletcheri</i>	Long-thumbed Frog	Palmer 1995
<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog	Molsher 1999
<i>Neobatrachus sudellae</i>	Common Spadefoot Toad	Catling 1988
<i>Platyplectrum ornatum</i>	Ornate Burrowing Frog	Palmer 1995
<i>Cyclorana platycephalus</i>	Water-holding Frog	Martensz 1971



needs of a fox. In contrast a large Diamond Python could weigh several kilograms, far more than what could be consumed in one siting. This may explain why the partially eaten bodies of two large (2.4 m) diamond pythons have been located by the senior author.

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# KOOKABURRA (*DACELO NOVAEGUINEAE*) ATTACKS EASTERN BLUE TONGUE LIZARD (*TILIQUA SCINCOIDES*)

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On 12 October 2015 at Mt Ainslie, in the Australian Capital Territory, we heard a strong Kookaburra alarm/warning call. We followed it and found the bird swooping at the ground. We looked closer and found a Blue Tongue Lizard (*Tiliqua scincoides scincoides*) was the bird's focus. On looking closely at the lizard we noticed a fresh wound on its side (Figure 1) presumably made by the

Kookaburra. We also saw that the Kookaburra had its nest in a hollow directly above (the bird flew into and out of it while we were there). We were surprised that a Kookaburra would object so strongly to a Blue Tongue in this way; we assume the bird was not preying on the lizard as it would seem to be too big to carry to the nest.

**Figure 1. Injuries to right side of midbody of Blue Tongue Lizard due to Kookaburra attack.**



While Kookaburras have occasionally been recorded preying on Blue Tongues (*Tiliqua rugosa*: Sedgwick, 1940; *T. nigrolutea*: Green *et al.*, 1988; *T. scincoides*: Parry, 1972: cover photograph; O'Connor, 2005), at least the latter three records involved juvenile lizards.

Kookaburras are commonly reported to feed on lizards and snakes (Parry, 1972; Blomberg & Shine, 2000). However, quantitative data from stomach content analyses suggest that reptiles are relatively rare contributions to the diet (Lea & Gray, 1935; Rose, 1973; Barker & Vestjens, 1989), with invertebrates predominating. Despite this, reptiles are potentially a much richer source of energy than invertebrates and may contribute more to the energy budget of the bird, and may be preferentially fed to young; hence, stomach contents may not be reliable estimators of diet when birds are feeding nestlings (S. Blomberg, pers. comm.).

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# SIGNIFICANT RANGE EXTENSIONS OF THE DWARF TREE FROG *LITORIA FALLAX* ALONG THE SOUTH COAST OF NEW SOUTH WALES

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## INTRODUCTION

The rate at which humans are homogenising the biota is of a greater magnitude than previously seen in Earth's history (Kraus, 2009). Much attention is given to non-native species that have been deliberately or accidentally introduced to new land masses particularly islands (Eldredge, 1988; Fritts & Rodda, 1998; Witmer & Fuller, 2011), with notable negative effects on the host environment. However, many species are expanding their ranges within land masses as a result of ecological changes resulting from human actions rather than by direct translocation of species.

The Dwarf Tree Frog *Litoria fallax* has a distribution in Australia that extends from Cooktown (Endeavour River) north Queensland to Melbourne, Victoria (Gillespie & Clemann, 2000; Atlas of Living Australia, 2015; Gullan, undated; Rowley et al., 2022). Historically the species did not extend south of Sydney but over the last 30 years it has colonised the south coast of New South Wales (NSW). This paper documents the spread of this frog along the coast and ranges south of Sydney and describes the species' historic distribution.

## HISTORIC ACCOUNTS OF THE DISTRIBUTION OF THE DWARF TREE FROG

Krefft (1863) makes no mention of the Dwarf Tree Frog being in the neighbourhood of Sydney. Fletcher (1889) states that he never "met" with this frog in the Sydney region but states that Krefft cited localities 30 miles from Sydney and the Blue Mountains. This indicates that between 1863 and his death in 1874 Krefft did find a few populations. Copland (1957), in his review of the Australian tree frogs, notes specimens from several locations in Sydney from as early as

1909. Moore (1961) also notes specimens from several locations in Sydney but not further south.

These accounts do not accord with the text description of the distribution of the Dwarf Tree Frog by Cogger (1975) which states that the Dwarf Tree Frog has a distribution extending from coastal and adjacent areas from central-western Queensland to southern NSW; the accompanying distribution map shows an area of occupation from about Cairns, Queensland to Wollongong NSW. Barker and Grigg (1977) state that the species occurs on the coast and ranges from north Queensland to central NSW. Their accompanying map shows a similar distribution to that of Cogger (1975), though the southern distributional limit appears to be slightly north of Cogger's limit and ends near Sydney. The works of Krefft (1863) and Fletcher (1889) suggest the Dwarf Tree Frog may not have originally occurred in the greater Sydney area. More recent observations made by the author and other amphibian biologists that lived in Sydney during the 1960s and 70s (M. Anstis, A. Parsons, pers. comm.) indicate small populations from 1970 (Table 1) but museum records indicate scattered populations from 1909.

## EXPANSION OF THE DISTRIBUTION OF THE DWARF TREE FROG TO THE SOUTH COAST OF NEW SOUTH WALES

In the early to mid 1990s I conducted fauna surveys in the south of the Sydney basin including the Cumberland plain in southwest Sydney, Illawarra and Shoalhaven regions. The Dwarf Tree Frog was detected at several farm dams during this period at Darkes Forest (1980), Appin (1992), Dapto (1995) and Fairy Meadow (Wollongong c.1995). The

first Dwarf Tree Frog detected in the adjoining Shoalhaven region to the south was in 1993. The frogs were associated with emergent aquatic plants in a farm dam in Kangaroo Valley where tadpoles and metamorphlings were observed (Daly, 2006).

Further south, isolated populations were found in 2000 at Ulladulla (Daly *et al.*, 2002) and Tura Beach (Daly & Senior, 2001), and Batemans Bay in 2001. Additional detections were made in the region at various locations between the 1990s and the present day, including Seven Mile Beach National Park (2015), Jervis Bay (2003, G. Merdith, pers.

comm.) and Stanwell Park (Daly *et al.*, 2009). Rowley *et al.* (2022), using a citizen scientist project, found 495 records of Dwarf Tree Frog outside the presumed native range as far south as Melbourne, Victoria.

The rate of expansion of Dwarf Tree Frog populations has accelerated as illustrated by the fact that the species was found at Brundee Swamp (near Nowra) in 2012 and by February 2013 had colonised the coastal town of Greenwell Point (Daly, 2015), a movement of some 10 km (Table 1). The Dwarf Tree Frog is now the most abundant species of amphibian in the Brundee area (Daly *et al.*, 2023).

**Table 1. Dates and locations where the Dwarf Tree Frog was initially detected in Sydney, Wollongong and the south coast of NSW**

Date	Location	Source/Reference
13.12.1970	Camden airport, western Sydney	Anstis, M., unpub. data
11.1.1976	6 km west Wilton, Sydney	Anstis, M., unpub. data
11.1.1976	Bellambi Ck. Mt Ousley, Wollongong	Anstis, M., unpub. data
14.12.1976	Farm dam, Darks Forest Rd, Darks Forest, Wollongong	Anstis, M., unpub. data
12.2.1994	Birkshire Park, western Sydney	Anstis, M., unpub. data
1992	Farm dams, Appin – western Sydney	Daly, G., unpub. data
1993	Farm dam Upper River Rd, Kangaroo Valley	Daly (2006)
1995	Farm dam, Dapto, Wollongong	Daly, G., unpub. data
1995?	Nursery at Fairy Meadow, Wollongong	Daly, G., unpub. data
6.12.1999	Ephemeral wetland 3 km south Ulladulla	Daly <i>et al.</i> (2002)
15.12.2000	Tura Beach golf course	Daly & Senior (2001)
8.1.2001	Farm dam Chakola, Kangaroo Valley	Daly, G., unpub. data
1.5.2001	Sydney Water land, Kangaroo Valley	Daly, G., unpub. data
8.2.2001	Dams in Catalina golf course, Batemans Bay	Daly, G., unpub. data
2001	Falls Creek, south Nowra	Daly, G., unpub. data
2003	Coastal Waters retirement village, Jervis Bay	Merdith, G., unpub. data
11.11.2008	Worrigee, Nowra	Daly, G., unpub. data
2009	Stanwell Park	Daly <i>et al.</i> (2009)
2012	Brundee Swamp, Nowra	Daly, G., unpub. data
2013	Greenwell Point	Daly (2015)



Currently the Dwarf Tree Frog is abundant throughout Kangaroo Valley and has a contiguous population east to Berry and south to the Shoalhaven River (Figure 1). Within the northern Illawarra there are still fragmented populations but these are rapidly expanding to amalgamate by presumably additional introductions and natural expansion of existing translocated populations.

To the south of the Shoalhaven River the species exists as fragmented populations, possibly as a result of separate introductions, but these are increasing their distributional boundaries as evidenced by the population around Jervis Bay that was initially associated with a retirement village west of Vincentia but now occupies farm dams in the broader area.

As Dwarf Tree Frogs are expanding in these established areas, it is possible that the frog will populate many of the currently vacant habitat areas on the coastal plain and could form a near contiguous population along the coast from north Queensland to southern Victoria.

Dwarf Tree Frogs are often found in association with emergent aquatic plants such as *Typha* and *Elaeocarpus* spp. in farm dams and coastal freshwater wetlands. The frog readily colonises disturbed rural landscapes where dams provide breeding and refuge habitat. The species appears to be rare or absent from areas of native vegetation derived from sandstone, such as the Dharawal reserves (Daly et al., 2009) and Morton National Park (Daly, 2006; Daly & Craven, 2007).

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**Figure 1. Amplecting Dwarf Tree Frog *Litoria fallax*, Nowra NSW**



Several populations were initially detected close to or within plant nurseries. In one instance frogs called at Fairy Meadow after a summer downpour while stationed on the stems of Golden Cane Palms *Dypsis lutescens*. These plants were sourced by that nursery from northern NSW and or southern Qld and it is suggested the frogs were translocated as a result of the nursery trade. In particular plants with multi-stems such as some species of palm or monocotyledonous plants such as Mattrush *Lomandra* sp. and the Iris *Dietes grandiflora* (a weed) are favoured as refuge sites by Dwarf Tree Frogs in winter. I have detected the species in the crowns of large Queen Palms *Syagrus romanzoffiana*, itself a weed species. Advanced Queen Palms were historically moved for landscaping and it is suggested that populations of the frog were also translocated during these actions.

## IMPLICATIONS OF THE SPREAD OF THE DWARF TREE FROG

Invasive organisms impact recipient communities in a number of ways, including the modification of the trophic structure within that community (Christy *et al.*, 2007; Fritts & Rodda, 1998). The Dwarf Tree Frog has been introduced several times to the south coast of NSW, presumably from different source populations. The frog is now abundant in many areas and would constitute a food item for predatory animals, thus changing the dynamic of those ecosystems. The ecological consequences of the introduction of this frog are unknown but it may compete with other tree frogs for food resources and facilitate the establishment of additional translocated species of animals by providing a food resource.

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# PREDATION OF AN ORANGE-NAPED SNAKE (*FURINA ORNATA*) BY THE INVASIVE CANE TOAD (*RHINELLA MARINA*)

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## INTRODUCTION

Since its introduction to Australia in 1935 the Cane Toad (*Rhinella marina*) has significantly impacted a number of native species, particularly larger predators that attempted to prey on them, and are subsequently poisoned, resulting in death (Doody *et al.*, 2009; Shine, 2010). While the Cane Toad is a recognised threat for many species, some have benefitted from the introduction of the toad by removing top predators, resulting in modification of the food web within an ecosystem (Doody *et al.*, 2013; Nelson *et al.*, 2010).

As predators, Cane Toads are opportunistic, feeding on a wide range of prey types, comprised mostly of terrestrial invertebrates (Hinckley, 1962; Lever, 2001; Zug & Zug, 1979). Cases of predation on small vertebrates are limited, but include small amphibians (including conspecifics), mammals (*Mus*), lizards (*Liasis*, *Emoia*) and some snakes (*Boiga*, *Anilius*, *Indotyphlops*) (Hinckley, 1962; Pizzatto & Shine, 2008; Pizzatto *et al.*, 2012; Reed *et al.*, 2007). There are few reports of *R. marina* preying upon native and introduced Australian snake species, including blindsnakes (*Indotyphlops braminus*, *Anilius guentheri* and *A. unguirostris*) (Pizzatto *et al.*, 2012; Reed *et al.*, 2007) and the Brown Tree Snake (Caudell *et al.*, 2002). However, there are no documented records of Cane Toad predation on species of elapid snakes.

Numerous studies have investigated the impact of Cane Toads on native fauna, par-

ticularly on the Northern Quoll (Oakwood, 2004; Woinarski *et al.*, 2008) and on predatory reptiles such as snakes (Brown *et al.*, 2011; Phillips *et al.*, 2003) and varanids (Doody *et al.*, 2009, 2013, 2017). Many of these studies have investigated the impacts of Cane Toads in relation to ingestion of toxins after predation attempts on the toad and to a lesser extent predation by the toads themselves.

Brown *et al.* (2011) predicted the vulnerability of snakes and a single pygopod lizard species to the Cane Toad invasion based on toxin resistance, anurophagy and distribution within the toads' current and expected range. Vulnerability to lethal toxic ingestion for some species (e.g. *Furina* and *Liasis*) was considered low due to their size or lack of recorded anurophagy, but the authors suggested that smaller individuals or species may be more vulnerable to ingestion by toads.

Here we document the predation of an Orange-naped Snake, *Furina ornata* Gray, 1842, by the introduced Cane Toad, observed near Emma Gorge at El Questro Wilderness Park in the Kimberley, Western Australia.

The Orange-naped Snake is a small terrestrial elapid (up to 650 mm total length) distributed widely throughout Western Australia, the Northern Territory and parts of Queensland and South Australia in a variety of habitats (Storr, 1981). Colouration is variable from reddish brown to yellow brown with dark edging to each scale forming a reticulum; head and neck black with an orange band across nape. The species is nocturnal and



appears to prey almost exclusively on skinks that are captured while sleeping (Shine, 1981).

## OBSERVATION

The observation took place on 27 April 2013 along the Emma Gorge cane toad fence at El Questro Wilderness Park in the east Kimberley (15°54'38"S 128°07'30"E), Western Australia, while collecting toads for a separate research project. At 1740 hrs, approximately 20 minutes after sunset, a large male toad was detected by eye shine. When approached, the toad was observed holding a small snake, which was struggling to escape and was attempting to bite the toad on its dorsum.

As the toad was approached it continued to consume the prey item and upon collection all that remained visible of the snake was a small portion of its tail. The snake was suspected to be *Furina ornata*, based on its apparent size and colouration of visible parts. The toad was collected and immediately placed into a bucket for holding, during which time disturbance was kept to a minimum. The snake was regurgitated during our return to the vehicle, after which it was confirmed as *F. ornata*. It is not known if the toad's regurgitation of the snake was in response to capture and handling, or a result of defensive response by the snake. The snake was still alive after regurgitation but died while being held overnight. Following regurgitation, the toad was placed with other toads collected and euthanased as part of another research project; however, no apparent symptoms suspected to result from possible bite and envenomation by the *Furina* were observed during the intervening period (approx. 10-15 minutes). Weather conditions during the observation were clear; temperature was approximately 28°C with little cloud cover and no wind (possibly protected by surrounding gorge walls). Moon phase was approaching a full moon.

## DISCUSSION

Little is known about the impacts of the Cane Toad on small vertebrate predators in the

ecosystems it invades. The species *F. ornata* has not previously been identified as a prey species of Cane Toads; however, dietary studies suggest that Cane Toads are highly opportunistic and will attempt to consume any small vertebrates (Lever, 2001; Shine, 2010; Zug & Zug, 1979). This record further indicates the highly opportunistic diet of this invasive species and that the risk of predation by the species poses yet another individual-level threat to small and even juveniles of larger reptiles occurring within the invaded range of the Cane Toad.

As the Cane Toad specimen was placed with other specimens collected following the regurgitation of the snake and later euthanased as part of another research project, it is unknown if envenomation by the *Furina* specimen occurred during any attempted bites during the predation event and if so, what impact this had on the Cane Toad, if any. The cause of death of the snake is unknown, though possibly attributed to suffocation during ingestion, crush injuries from the toad during predation or subsequently in the bucket following regurgitation, or ingestion of lethal toxin when attempting to bite the toad in defence.

The decline of Australian snakes, particularly frog-eating elapid species, is often linked to ingestion of toxins when depredating Cane Toads (Brown *et al.*, 2011; Phillips *et al.*, 2003; Shine, 2010). Our record suggests that not only adults of large elapid species may be impacted by the Cane Toad, but also hatchlings and small bodied species are also vulnerable to predation by toads, particularly small elapid species including *Furina*, *Brachyuropsis* and *Suta*. Further study would be required to determine the extent and severity of impact by the toad on small or juvenile snakes.

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## ABSTRACT

Some observations on ontogenetic development of dorsal colour pattern (including photos), and description of ventral colour pattern and habitat preferences are provided for three live individuals of *Delma elegans* collected from 106–109 km WNW of Newman, Western Australia.

## INTRODUCTION

Kluge (1974) revised the family Pygopodidae and in the process described seven new *Delma* species. The Pilbara endemic *Delma elegans* was included among these new species, described from a male holotype from Mount Herbert (21°20'S 117°13'E) and two paratypes, one each from Tom Price townsite (22°42'S 117°47'E) and Tambrey (21°38'S 117°36'E), all from Western Australia. The genus *Delma* is the most speciose in the family and currently contains 22 recognized species, some of which are very abundant and frequently encountered. However, *D. elegans* remains poorly known and little has been published on this species since Kluge's revision despite the accumulation of large amounts of field data for most other *Delma* taxa. Jennings *et al.* (2003) produced a phylogeny of 32 of the 38 extant Pygopodidae species described at that time, based on morphology and mitochondrial/limited nuclear DNA, but excluded six species (including the two *Delma* species, *D. elegans* and *D. plebeia* De Vis, 1888) from their analyses. This was presumably because of a lack of available genetic material for these six species, and thus the relationship of *D. elegans* to other *Delma* species was not defined at this time. More recently Brennan *et al.* (2016), in a more thorough analysis that included genetic material for all *Delma* species described to

date, recovered *D. elegans* as the most basal member of a 'northwestern' clade comprising *D. borea* Kluge, 1974, *D. tincta* De Vis, 1888, *D. pax* Kluge, 1974, *D. tealei* Maryan, Aplin & Adams, 2007 and *D. desmosa* Maryan, Aplin & Adams, 2007 though the relative closeness of this relationship was uncertain based on the discordance between their nuclear and mitochondrial DNA datasets. The 'northwestern' clade was first designated the *D. tincta* species-group by Shea (1991). *Delma elegans* is currently known to occur only in the Pilbara region of Western Australia, from Nimingarra (20°24'S 120°01'E) in the north to 9 km east of Mt Maguire (23°21'S 117°50'E) in the south, and from 50 km west of Pannawonica (21°40'S 115°50'E) in the west to Old Meentheena (21°17'S 120°28'E) in the east (based on Western Australian Museum records), and appears to be restricted to the rockier parts of this region.

I visited several Pilbara sites in close proximity to each other (ca 106–109 km WNW of Newman, Western Australia) from 31 March–9 April 2012, and was fortunate to encounter three individuals of *D. elegans*. The data obtained provide some information on its colour pattern variation and ontogeny, habitat requirements and distribution. These observations are provided below.

Times cited are Australian Western Standard Time (AWST) in military format. Live specimen measurements (SVL: snout-vent length; TL: tail length) were taken with a ruler to the nearest 0.5 mm. Latitudes/longitudes are provided using Map Datum WGS 84.

## OBSERVATIONS

**Site 1:** 109.052 km WNW of Newman, Western Australia at 22°52.228'S 118°48.317'E, 746 m elevation.

**Figure 1. Lateral view of head/forebody of *D. elegans* from Site 1, SVL: 74 mm. (Photo: M. Peterson).**



One adult *D. elegans* (SVL: 74 mm; TL: 287 mm [complete original tail without regeneration]) recorded at 15:42 hrs on 7 April 2012 in a funnel-trap in a creekline/moist zone in a narrow valley between two low rocky ironstone hills. The area was vegetated with a low species of *Corymbia* (ca 5 m tall) forming the upperstorey, several species of *Acacia* and a species of *Dodonaea* the midstorey (up to 2 m tall), and the resinous 'soft spinifex' grass *Triodia epactia* S.W.L. Jacobs and other diverse grass genera and species (up to 1 m tall) the understorey. The soil type was a red-brown clay with many small stones and ironstone pisoliths scattered through the soil profile.

Colour notes in life (Figure 1): dorsum with head possessing a dark blackish transverse interocular band not clearly demarcated from slightly paler anterior of head by much paler interspaces; three evenly blackish well-demarcated transverse postocular bands present and separated by greyish interspaces of two-scale width; a reddish body and basal third of tail, and a yellow-brown distal two-

thirds of tail. Laterally head with black postocular bands separated by white rather than grey interspaces and with these bands anteriorly angled ventrally. Venter white under entire body to vent, with a light rosy pink flush present under tail for its entire length, throat additionally with black markings mostly on lateral parts.

**Site 2:** 106 km WNW of Newman, Western Australia at 22°48.377'S 118°53.123'E, 770 m elevation.

One adult *D. elegans* (SVL: 78 mm; TL: 306 mm [complete original tail without regeneration]) recorded at 09:45 hrs on 3 April 2012 in a funnel-trap on a rocky lower scree slope of a large ironstone hill. The area was vegetated with *Eucalyptus leucophloia* Brooker (to 6 m tall) and an occasional low species of *Corymbia* forming the upperstorey, *Acacia* species the midstorey (up to 1.5 m tall), and the resinous 'hard spinifex' grass *Triodia wiseana* C.A. Gardner the understorey (up to 0.7 m tall).



**Figure 2.** Lateral view of head/forebody of *D. elegans* from Site 2, SVL: 78 mm. (Photo: M. Peterson).



Colour notes in life (Figure 2): dorsum with head possessing a grey-brown transverse interocular band not clearly demarcated from slightly paler anterior of head by much paler interspaces; three grey-brown well-demarcated transverse postocular bands narrowly margined with black are present separated by greyish interspaces of two-scale width; a reddish body and basal third of tail, and a yellow-brown distal two-thirds of tail. Laterally head with black postocular bands separated by grey interspaces and with these bands anteriorly angled ventrally. Venter white under entire body to vent, with a light rosy pink flush present under tail for its entire length, throat additionally with black markings mostly on lateral parts.

**Site 3:** 109 km WNW of Newman, Western Australia at 22°48.217'S 118°51.185'E, 706 m elevation.

One mature adult *D. elegans* (SVL: 90 mm; TL: 234 mm [regenerated tail: 204 mm orig-

inal + 30 mm regeneration]) recorded initially at 10:45 hrs on 2 April 2012 in a *Triodia epactia* tussock on an ironstone plateau plain with a red-brown clay soil. This individual then moved rapidly to hide under fallen timber a few metres away. The area was vegetated with an occasional low species of *Corymbia* and *Acacia aneura* Benth. (to 6 m tall) forming the upperstorey, other smaller *Acacia* species (up to 1.7 m tall) occupying the midstorey, and *Triodia epactia* and low pea species and small forbs the understorey (up to 1 m tall).

Colour notes in life (Figure 3): dorsum with entirety of head and nape brownish and without obvious darker transverse bands. Laterally head with postocular bands present, and with yellow flush covering pale interspaces nearly to venter below. Venter white in anterior half of body with a light rosy pink flush present from 45 mm from snout-tip to vent, and with slightly more intense pink under tail for its entire length; throat addition-

**Figure 3. Lateral view of head/forebody of *D. elegans* from Site 3, SVL: 90 mm. (Photo: M. Peterson).**



ally with black markings mostly on lateral parts.

### DISCUSSION

The ontogenetic development of colour pattern in *D. elegans* is consistent with that of most other *Delma* species that possess dark transverse bands on the head and nape which are not linked to regional variation or subspeciation (e.g. *D. borea*, *D. tinctoria*, *D. pax*, *D. fraseri* Gray, 1831, *D. petersoni* Shea, 1991, *D. molleri* Lütken, 1863; see Maryan *et al.* (2007) for description of ontogenetic change in other members of the *D. tinctoria* species-group). Juveniles of these species possess black or very dark distinct interocular and postocular bands, and as they age and increase in SVL, the melanistic markings decrease in intensity until the transverse bands often completely disappear dorsally. In the case of *D. elegans*, mature individuals dorsally lose the evenly dark central coloration of their transverse bands between 74

and 78 mm SVL, but dorsally retain the dark margins of these transverse bands as well as the demarcating pale interspaces between the bands at 78–81.5 mm SVL (latter measurement based on Kluge, 1974: 87, figs. 50a-c), and eventually entirely lose the dark transverse bands and pale interspaces dorsally at 90 mm SVL. However, the dark transverse bands are retained laterally as part of the colour pattern at all of these SVLs. Simultaneously the pale interspaces between the transverse bands laterally become progressively suffused with a yellow flush with an increase in size, especially between 81.5–90 mm SVL. One colour pattern feature that appears to be diagnostic for *D. elegans* is that the lateral extremities of the postocular bands are anteriorly directed, and this appears to only occur otherwise in the allopatric species *D. plebeia* from eastern Australia, unlike the transversely directed extremities of these bands in other *Delma* species.

The habitat observations in this paper support



the view that *D. elegans* primarily occurs on the harder soils of the Pilbara uplands from the rocky summits and scree slopes to the nearby stony plateau plains and narrow valleys immediately below. During the field work I found it syntopic with *D. nasuta* Kluge, 1974 at Site 2, and sympatric (but not syntopic) with *D. tinctoria* in the general survey area. In the Pilbara I have not encountered *D. elegans* in the sandy areas occupied by *D. pax* and *D. nasuta*, or the non-stony clay soils occupied by *D. tinctoria*. Additionally, I have encountered *D. elegans* in areas occupied by two different species of *Triodia* (Poaceae): *T. epactia* and *T. wiseana*.

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# INTERSPECIFIC AGGREGATIONS OF THREE ELAPID SNAKE SPECIES ON THE MITCHELL GRASS PLAINS, BARKLY TABLELANDS, NORTHERN TERRITORY, AUSTRALIA

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## INTRODUCTION

Elapidae is the largest family of Australian snakes, with 26 terrestrial genera comprised of 110 species (Wilson & Swan 2021; Nankivell *et al.*, 2023). Of this diverse family, some of the most frequently encountered are snakes of the genera *Pseudonaja* (Brown Snakes) and *Demansia* (Whipsnakes). This is due to their active and predominantly diurnal nature (Shine, 1979, 1980, 1989). However, notes on the ecology of certain species within these genera remain relatively scarce. Ecological knowledge is particularly lacking in those restricted to the cracking clay soils of the Mitchell Grass Plains; such as the Speckled Brown Snake (*Pseudonaja guttata*), Ingram's Brown Snake (*Pseudonaja ingrami*) and Crack-dwelling Whipsnake (*Demansia rimicola*). These species can be difficult to locate as they spend much time deep in earth cracks and observations of these species usually end abruptly when the snakes retreat below ground (Shea & Scanlon, 2007; Wilson & Swan, 2021).

The Speckled Brown Snake *P. guttata* (Parker, 1926) has an average snout-vent length (SVL) of 70 cm but may reach a SVL of more than 100 cm (Shine, 1989). It is restricted to the Mitchell Grass Plains and channel country of central Northern Territory, western Queensland and north-eastern South Australia (Jolly *et al.*, 2023). *Pseudonaja guttata* is known to feed on frogs, reptiles and mammals (Shine, 1989). Ingram's Brown Snake *P. ingrami* (Boulenger, 1908) has an average SVL of 121 cm, but may exceed 140 cm (Shine, 1989). It

is restricted to the Mitchell Grass Plains and channel country of central Northern Territory and western Queensland (Jolly *et al.*, 2023). *Pseudonaja ingrami* is thought to be a mammal specialist (Shine, 1989). Crack-dwelling Whipsnakes (*D. rimicola* Scanlon, 2007) may reach up to 74 cm SVL. *Demansia rimicola* is mostly restricted to the Mitchell Grass Plains and channel country of north-eastern Western Australia, central Northern Territory, western Queensland, north-eastern South Australia and north-western New South Wales (Shea & Scanlon, 2007). *Demansia* are alert and largely diurnal snakes that are thought to predominantly feed on lizards (Shine, 1980).

The Barkly Tableland is a semi-arid environment with a climate that is influenced by the northern summer monsoon (Fisher *et al.*, 2002). Located in the central Northern Territory and spanning east into north-western Queensland, the Barkly Tableland largely consists of sparse open plains. The plains are dominated by Mitchell Grass (*Astrebla* spp.) and are mostly devoid of trees and shrubs (Foran & Bastin, 1984). When the clay soils, often known as blacksoil, dry they form a vast network of cracks that provide shelter for many species (Foran & Bastin, 1984; Wilson & Swan, 2021). These cracks appear to be essential to the survival of the blacksoil endemic herpetofauna, providing shelter from extreme surface temperatures, predators and fire (Homan, 2014). The ability for these species to remain either dormant or active below the surface may also reduce water loss during seasonal dry periods and



drought. For this reason, blacksoil plains often seem like a desolate and lifeless landscape, with the majority of terrestrial animals sheltering below ground. However, when substantial rainfall occurs, the soil-cracks close (Fisher *et al.*, 2002), limiting available shelter sites. It is during and after these flooding events that frogs breed in huge numbers, providing food for a variety of species including *P. guttata* and *D. rimicola* (Shine, 1989; B. Schembri & G. Vas, pers. obs.).

Here we provide observations of one such flooding event that led to a large interspecific aggregation of elapid snakes and frogs and binge-feeding behaviour.

## OBSERVATIONS

During March 2014, the authors spent seven days on the Barkly Tableland in search of herpetofauna to photograph. After a largely fruitless few days along the northern half of the Tablelands Highway, we ventured further south in hope of better conditions. The area we had searched to the north was flooding and, although we encountered *D. rimicola*, it was concluded that the expansive flooding had likely dispersed the herpetofauna. As we travelled south the landscape became drier and we saw no reptiles until we passed a swampy patch of blacksoil on 26 March. The swamp was quite narrow, in the form of stretches of water one to three metres wide, scattered intermittently along the roadside for approximately 500 meters. The damp soil was restricted to the eastern side of the road and became dry within 200 m of the road. We encountered two dead snakes adjacent to the swamp, an adult *P. guttata* and an adult *D. rimicola*. Both snakes were presumed to have been killed by road traffic earlier that day.

We returned to the swamp on the morning of 27 March. The previous night was 9°C, the morning was clear but windy and the daytime high was approximately 26°C. At 9 am we began walking along the edge of the swamp and quickly encountered a *P. guttata*. There were thousands of juvenile Knife-footed Frogs (*Cyclorana cultripes*) moving around the

swamp and we could constantly hear frog distress calls emanating from various locations. As the morning warmed up, we encountered large numbers of snakes. *Pseudonaja guttata* and *D. rimicola* were seen pursuing, capturing and consuming *C. cultripes* on many occasions on the mornings of 27 and 28 March (Figures 1-4). While Waterholding Frogs (*Cyclorana platycephalus*) were also abundant we did not observe them being consumed by snakes, although we did observe *C. platycephalus* feeding on *C. cultripes* (Figure 5). On one occasion, a 100 cm *P. guttata* was disturbed and during its thrashing defensive display it regurgitated seven freshly eaten *C. cultripes*. *Pseudonaja ingrami* were also recorded but we did not witness them feeding.

*Pseudonaja guttata* were regularly seen foraging in the water (Figure 2), sometimes with their head and fore-body completely submerged. Two *P. ingrami* were observed, with the smaller specimen found on the water's edge amongst two *P. guttata* that were feeding on frogs. The other, much larger, *P. ingrami* was discovered sitting in the water with its head and tail on bank. When it sensed our presence, the snake quickly submerged in the shallow (<40 cm) murky water and remained totally submerged for almost two minutes.

A flock of Black Kites (*Milvus migrans*;  $n > 50$ ) was present for the entire time spent at the swamp and Little Eagles (*Hieraaetus morphnoides*) also visited the site intermittently. We regularly witnessed *M. migrans* capturing and consuming frogs but we did not see any raptors attempt to capture a snake.

Over the six hours we spent surveying the swamp, 118 elapid snakes were observed. Of these, 103 were *P. guttata*, 13 were *D. rimicola* and two were *P. ingrami*. We observed both immature and adult snakes of each species. *Pseudonaja guttata* ranged from 35-110 cm, *D. rimicola* ranged from 25-70 cm and *P. ingrami* ranged from 60-140 cm. We did not formally measure any snakes; the lengths given are estimates.

**Figure 1. *Pseudonaja guttata* foraging along shrinking pools of water.**  
**Photo: Brendan Schembri.**



**Figure 2. *Pseudonaja guttata* foraging underwater.** Photo: Brendan Schembri.





Figures 3, 4. *Pseudonaja guttata* consuming *Cyclorana cultripes*. Photos: Brendan Schembri.





## DISCUSSION

We suggest that this large aggregation of elapid snakes was created by flooding of a large area in the weeks or months prior to our observation. As the water receded, the frogs and snakes followed this diminishing resource, which eventually led to abnormally high densities of frogs and elapid snakes.

The aquatic foraging behaviour observed suggests that *P. guttata* was also hunting tadpoles that were in high concentrations in the shallow pools, although we did not witness tadpole consumption, nor were tadpoles present among the regurgitated food items examined from one snake. The hunting and threat avoidance behaviour displayed by *P. guttata* and *P. ingrami* led us to conclude that these snakes are quite suited to a semi-aquatic lifestyle even though such environments are only sporadically present in their distribution.

Although *P. guttata* were abundant, often in the open, seemingly poorly camouflaged and were regularly less than 50 cm total length, we did not observe any raptors attempting to capture snakes. *Milvus migrans* and *H. morphnoides* have both been seen to predate on snakes, including highly venomous elapid species (H. Cook, pers. comm.; M. Carter, pers. comm.). Our observations indicate that raptor prey preference could be driven by climatic conditions on the Barkly Tableland, with less threatening prey species being preferred when readily available.

Although we observed many individual snakes feeding, the *P. guttata* that regurgitated seven undigested *C. cultripes* highlights the binge-feeding behaviour of this species. *Demansia rimicola*, believed to be a lizard specialist (Shine, 1980), was seen pursuing and capturing *C. cultripes* on open ground and others were found already consuming



frogs. Unfortunately, the timid nature and swiftness of this species made photographic documentation of these behaviours extremely difficult. *Pseudonaja ingrami* are believed to be specialist mammal-feeders (Shine, 1989) but the behaviour we observed from the two individuals seen suggests that they were also foraging for frogs. All three elapid species were found in very close proximity to one another, but no snake predation was observed.

The bust and boom cycle of the Mitchell grass plains is the likely driver of the binge-feeding behaviour that we observed. Limited access to the region, particularly during wet conditions, is likely responsible for the lack of previous observations in these habitats. A similar event, though on a smaller scale, was encountered 20 km north of our own observations in late March 2020 (C. Jolly, pers. comm.), and we suggest that although it is an uncommon sighting, these interspecific elapid aggregations may be a normal occurrence under suitable conditions.

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# TACTICS USED IN COMBAT BETWEEN COMPETING MALE PERON'S TREE FROGS *LITORIA PERONII*

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## INTRODUCTION

Reviews of anuran social biology have identified that frog species with prolonged breeding species exhibiting a similar behavioural sequence when competing for mates (Wells, 1977; Dyson *et al.*, 2013). Prolonged breeding species are those that call for longer periods within a year, where an arbitrary threshold of >1 month of calling per breeding has been used to characterised prolonged breeding amphibians (Wells, 1977). Calling males of such species will space out relatively evenly near a breeding habitat, and each male maintains an exclusive territory where rival males are not tolerated (Robertson, 1984). A contact call will be issued if a rival calling male enters another male's territory (Wells, 1977). The contact call is different to the usual breeding advertisement call of the species. If the intruding frog remains, male to male combat may ensue, and the loser of the fight will stop calling or vacate the territory.

Social interactions of Australian anurans are poorly studied and rarely documented. Only one study in Australia has investigated social biology of hylid frogs (Morrison *et al.*, 2001). The rest of the research is focused on four genera of myobatrachid and limnodynastid frogs, *Adelotus*, *Crinia*, *Pseudophryne* and *Uperoleia* (Pengilley, 1971; Robertson, 1984, 1986a,b, 1990; Katsikaros & Shine, 1997; Lemckert, 2005). Of these studies, combat and male territoriality in amphibians has only been explored for *Adelotus brevis*, *Uperoleia rugosa* and four *Pseudophryne* species (Pengilley, 1971; Robertson, 1986b; Katsikaros & Shine, 1997).

There is a variety of tactics used in combat between competing male Australian frog species and it is unknown if combat methods are taxon specific or body structure specific. The small myobatrachid frogs of the

*Pseudophryne* and *Uperoleia* genera (snout-vent length: ~30-35 mm) will grapple intruding males with the forelimbs and attempt to toss them out of their territory (Pengilley, 1971; Robertson, 1986b; Anstis, 2013). The larger myobatrachid frog *Limnodynastes peronii* (SVL: ~70 mm) compete by wrestling while puffed up and attempt to push each other underwater (Clyne, 1967). The small hylid *Litoria bicolor* will engage in head-to-head grappling in attempts to dislodge the opponent from the perch (Anstis, 2013).

Peron's Tree Frog *Lit. peronii* is one of the most common hylids on the east coast of Australia, yet only brief anecdotes have identified that male Peron's Tree Frogs compete aggressively (Wells, 1977). Specific tactics used in combat of male *Lit. peronii* mostly have yet to be documented. In this article I describe three observations of combat between competing male Peron's Tree Frogs and discuss tactics males use in combat.

## METHODS

Observations were made by approaching the competing male frogs carefully with a head torch on a dimmed light setting and with minimal disturbance to the interacting frogs.

## OBSERVATIONS

### Observation 1

The first instance of combat between two male *Litoria peronii* was observed on 9 December 2014 at 21:02 hrs in a backyard in Kirrawee, Sydney, NSW (34°2'32.70"S 151°4'28.21"E). There were five calling males spaced around a small pond (surface area: ~0.4 m<sup>2</sup>, depth: 0.3 m), with only one female near the pond. Two of the males were near one observable female. No other frog species were present.

One male was calling from a steel panel

fence at 200 cm above the ground (Frog 1), while the other was calling from a branch of a *Camellia* (*Camellia reticulata*) approximately 160 cm above the ground (Frog 2). The two male frogs were spaced approximately 70 cm from each other and were both within 100 cm of the female. Frog 2 began issuing a contact call while Frog 1 continued with a mating call. After emitting 45 contact calls back and forth, Frog 2 jumped onto the steel fence within 20 cm of Frog 1. Frog 1 continued issuing mating calls. Frog 2 then initiated combat and jumped on the back of Frog 1 and placed its hand on the vocal sac of Frog 1. Frog 1 responded by pushing and kicking away the hands and feet of Frog 2 which resulted in Frog 2 falling 200 cm to the ground. Frog 1 continued issuing mating calls from its position on the steel fence. Frog 2 relocated to a position farther from Frog 1 on a lower branch of the *Camellia*, approximately 150 cm away from Frog 1 and 50 cm above the ground. During the remaining 5 minutes of observation, Frog 2 did not emit any calls.

## Observation 2

The second instance of combat between two male *Lit. peronii* was observed on 9 October 2015 at 19:36 hrs at Ryan's Swamp (surface

area: ~26,350 m<sup>2</sup>, depth: ~1.4 m), Booderee National Park, NSW (35°9'39"S 150°39'58"E). Twenty+ *Lit. peronii* were calling and at least three females were observed within a 1 m radius of the competing males. Other species calling at the same time included *Crinia signifera*, *Limnodynastes peronii*, *Lit. fallax*, *Lit. tyleri* and *Uperoleia tyleri*.

One male *Lit. peronii* was calling from a semi-submerged log approximately 40 cm above the ground (Frog 1) while another male was calling from a reed next to the log approximately 60 cm above the ground (Frog 2). A female was also sitting on the log approximately 30 cm away from Frog 1 and approximately 60 cm away from Frog 2. Both Frog 1 and Frog 2 were initially spaced approximately 50 cm apart. Frog 2 issued a contact call four times before jumping onto the log approximately 20 cm away from Frog 1. Frog 1 continued issuing mating calls during the contact calls being emitted by Frog 2, and despite Frog 2 being within a 20 cm proximity. Frog 2 then engaged Frog 1 in combat by initially jumping on the back of Frog 1 from a side on position and positioned its hand on the vocal sac of Frog 1 (Figure 1). Frog 1 stopped issuing mating calls and

**Figure 1. Two male Peron's Tree Frogs engaged in combat. Note the hand placement (arrowed) of the attacking male (Frog 2) on the vocal sac of the defending male (Frog 1). Photo: C. Beranek.**



assumed a submissive posture. Frog 2 attempted to push Frog 1 off the log. Frog 1 jumped off the log onto nearby vegetation. Frog 2 then began issuing mating calls from the log, with no intervention from Frog 1 for the remaining 7 minutes of observation.

### Observation 3

The third instance of combat between two male *Lit. peronii* was observed on 19 November 2021 at 21:47 hrs, during amphibian surveys at a private property in Kurmond (33°32'49"S 150°42'10"E). The surveys were conducted at a farm dam which had a surface area of ~416 m<sup>2</sup> and was ~1.7 m deep at the deepest section. There were around ~40 *Lit. peronii* calling in and around the perimeter of the pond, with several other species also calling including *C. signifera*, *Lit. fallax*, *Lit. latopalmata*, *Lit. tyleri*, *Lit. verreauxii*, and *U. laevigata*. Frog 1 was initially issuing mating calls ~30 cm from the bank on overhanging dead vegetation (~40 cm in height).

Frog 1 began emitting contact calls after Frog 2 moved to a position on a sprouting *Eucalyptus* sp. within ~70 cm from Frog 1 and began issuing mating calls (~60 cm in height). Two contact calls were issued by frog 1, yet Frog 2 continued issuing mating calls. Frog 1 jumped onto the stem that Frog 2 was positioned on and jumped on the back of Frog 2 and engaged in grappling combat. Frog 2 did not appear to fight back but swung into a position where they were hanging off the stem of the eucalypt with the backs of both frogs facing the water of the pond. In this position, Frog 1 placed its left foot on the foot of Frog 2, then attempted raking motions with its right foot, targeting the back left foot of Frog 2. This behaviour appeared to be an attempt to dislodge Frog 2 from the stem. After the raking motions of Frog 1 ceased, Frog 1 positioned itself in a dominant position over Frog 2 and remained in this position for 1 minute and 45 seconds, where the right foot of Frog 1 was positioned on the face of Frog 2, and the left foot was positioned on the left leg of Frog 2. Frog 1 issued two contact calls while in this position. Frog 2 remained in

a submissive position hanging upside down, however it kept its vocal sac inflated. Frog 1 jumped away and assumed a position ~1 m from Frog 2 and resumed issuing mating calls. Frog 2 remained in the same submissive position for ~2 minutes after Frog 1 left, then distended its vocal sac and moved down the stem of the eucalypt and did not resume issuing mating calls for the rest of the observation period (~9 minutes and 30 seconds).

### DISCUSSION

My observations confirm what is known to occur in competitive interactions between males of prolonged breeding frog species (Wells, 1977). In all three instances competing males were issuing mating calls while evenly spaced out around a breeding pond. The defending male issued contact calls to a nearby competing male. If the contact call did not discourage the intruding male, the defending male physically engaged the intruder in combat (Wells, 1977). However, in observation 1 the frog which issued the contact call lost the combat where in observations 2 and 3, the frog which issued the contact call won the combat. It is unclear what factors enable a frog to win combative bouts and this needs to be subjected to experimental studies to understand the factors involved to further our understanding of anuran social biology.

There were commonalities among the tactics that males used in combat among the three observations. In all instances the frog which issued the contact call was the aggressor and jumped on the back of the intruder and attempted to grapple them from this position. In two instances the aggressor also placed their hand on the vocal sac of the intruder (Figure 1). Similar observations have been made of Peron's Tree Frogs combat from Berowra Heights (Anstis, 2013). A possible explanation of this tactic is that the aggressive male Peron's Tree Frog is attempting to suppress the mating calls of intruder males. This could act by restricting the amount of air contained in the vocal sac, resulting in insufficient airflow to enable sound emission. If this



explanation is true, it is possibly the first instance of this behaviour to be documented in frogs worldwide. To further our understanding of Australian frog social behaviour and in particular, male combat, research is needed to ascertain whether the combating males place their hand deliberately on the vocal sac of their competitor to suppress them from issuing mating calls or whether this action is just an artefact of the way they physically engage during amplexus and in combat.

I conclude that *Lit. peronii* presents an optimal species for investigations in understanding amphibian male combat. Some factors that make it an ideal subject are: (1) it is common and widespread, (2) it has a loud conspicuous mating call and an obviously different contact call (Anstis, 2013) and (3) their behaviours are observable under dimmed light conditions. Controlled experiments could be used to understand what factors influence combat success. Field-based observation studies could be used to determine spatial and temporal predictors of the probability of contact calls. Both these approaches are important to increase our overall understanding of anuran social behaviour.

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# A LIVE CARTRIDGE IN THE STOMACH OF A PYGMY COPPERHEAD *AUSTRELAPS LABIALIS*

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## INTRODUCTION

The smallest species among the Australian Copperhead (*Austrelaps*) taxa, *A. labialis* (Jan, 1859) is endemic to South Australia, documented throughout Kangaroo Island, restricted to 150 km<sup>2</sup> total area in the Southern Mt Lofty Ranges and patchy distribution on the Fleurieu Peninsula (Read & Bedford, 1991; S. Scott & Biffin, 2021). A moderate-sized elapid, ranging up to 87 cm, it is found in high altitude stringybark forest with dense understory in the Mt Lofty Ranges to varying habitats on Kangaroo Island including closed woodlands, but also open coastal dunes, agricultural areas and grasslands (Read & Bedford, 1991; S. Scott & Biffin, 2021). Diurnal to crepuscular in activity, *A. labialis* are active foragers, primarily feeding on small skinks, although frogs, geckos, insect pupae, lizard eggs and non-native mice have also been recorded (Shine, 1987). Individual *A. labialis* display behavioral agitation when separated from conspecifics, indicating the species may socially buffer as found in *Crotalus helleri* (Bedford, 1989; Martin et al., 2023).

In 2005 I was asked to continue a morphological study on *A. labialis* specimens located in the South Australian Museum (SAM), after fellow herpetologist Erik Attnarsson passed away. This paper describes documentation of an ingested foreign body from an individual held within the museum collection.

## OBSERVATION

During this study I examined specimen R29574, collected in 1985 at Pelican Lagoon Conservation Park, Kangaroo Island (35°49'S 137°47'E) by SAM senior curator, Terry

Schwaner. Specimen R29574 was identified as an intact male, with a snout-vent length of 36.1 cm. Blue staining was noticed during examination on the ventral scales, part way down the body and the specimen was opened for inspection. The cause of colouration was oxidation by an unfired firearm cartridge, 24 mm long increasing from 5.2 mm star crimp to a 7 mm rim, swallowed from the tapered end (Figure 1). This cartridge was identified as a .22 ratshot/birdshot, by Rebel Gun Works in Brisbane, Queensland, Australia. As the cartridge was unfired and not inside an ingested prey item, this suggests that the cartridge was swallowed voluntarily and as the individual was collected by a senior biologist, not just as a donation by a member of the public, this excludes the possibility of deliberate interference with the specimen.

## DISCUSSION

Ingested foreign objects have previously been recorded in a variety of wild and captive reptiles. *Boiga irregularis* show increased chemosensory interest toward soiled tampons which they will also ingest, demonstrating their willingness to consume scented inanimate objects (Chiszar et al., 1993). Foreign objects from wild snakes have been removed from differing species by Townsville Veterinary Clinic including plastic chicken eggs from a *Liasis fuscus*, vehicle parts from a *B. irregularis* and a tennis ball from a *Morelia spilota mcdowelli* (Trish Prendergast pers. comm.; <https://www.theguardian.com/environment/video/2017/feb/09/snake-regurgitates-tennis-ball-after-mistaking-it-for-food-video>). Golf balls and artificial eggs used in bird nest boxes have been ingested by free-ranging snakes, with removal by veterinarians not

**Figure 1. *Austrelaps labialis* (South Australian Museum R29574) with unfired cartridge removed from stomach.**



always a success (G. Scott *et al.*, 2021). In captivity, pythons have been known to consume plastic plants used as decoration leading to intestinal obstruction, barbecue tongs used for offering food and even a full beach towel (Blasiola *et al.*, 1982; Almond, 2016; <https://www.facebook.com/watch/?v=502163387164246>). Mechanical and physiological effects of ingestion of foreign objects include travelling less and slower than conspecifics, loss of body condition, scale loss and pressure sores (Camus *et al.*, 1998; Fitch & Shirer, 1971; Murray *et al.*, 2010). Additionally, elevated lead levels from consumption of meat containing bullets and zinc toxicosis have been recorded from ingesting metal objects (Camus *et al.*, 1998; Grade *et*

*al.*, 2019). There is the possibility the cartridge may have hindered the snake's survival by reducing movement, impacting the drive to eat, internal obstruction or increasing the need to bask to digest the object, increasing the probability of collection.

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**PREDATION OR SCAVENGING ON AN ADULT BROWN TREE SNAKE, *BOIGA IRREGULARIS* (REPTILIA: SERPENTES: COLUBRIDAE: BOIGINAE), BY A KOOKABURRA, *DACELO NOVAEGUINEAE* (AVES: CORACIIFORMES: ALCEDINIDAE: HALCYONINAE)**

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## INTRODUCTION

The Brown Tree Snake, *Boiga irregularis* (Serpentes: Colubridae: Boiginae) is a large arboreal nocturnal snake with a natural range in eastern Indonesia, New Guinea, northern Australia, and eastern Australia as far south as the Sydney region, New South Wales (Cogger, 2014). However it has been introduced by human vectors to some Pacific Ocean islands such as Guam where it has established and become a major extinction threat to endemic avifauna (Rodda *et al.*, 1999). The Kookaburra, *Dacelo novaeguineae* (Coraciiformes: Alcedinidae: Halcyoninae) is a large diurnal kingfisher with a distribution in eastern mainland Australia (Simpson & Day, 2010) and natural diets comprise insects, and small reptiles, frogs, birds, and mammals (e.g., Parry, 1970; Barker & Vestjens, 1989; Blomberg & Shine, 2000; Allen *et al.*, 2009). Although *D. novaeguineae* has wide repute as a snake predator, such prey items are seldom identified to species level in the literature (see cross-indices and citations in Shea, 1987, given as *Dacelo gigas*). This note reports a case of either predation or scavenging on *B. irregularis* by *D. novaeguineae*.

## OBSERVATIONS

Observations were recorded at 'Avocado Heights', a fruit-growing property located near Emerald Beach, ca 26 km north of Coffs Harbour, New South Wales. A brick residential dwelling and several outbuildings are situated atop a concrete platform located in a levelled area near the top of a coastal hill that had been cleared of native vegetation and

surrounded by ornamental shrubs, small trees, gardens, and lawns. A fruit orchard exists on steep slopes below the buildings. The nearest native vegetation is in Orara East State Forest at the top and on western slopes of the ridge which adjoins the western and northwestern boundaries of the property. At ~1700 hrs on 15 April 2017 (air temperature ~21°C, 1/8 cloud cover, no wind), the first author was seated on the verandah of the house (at 30.164775°S 153.158819°E, datum WGS84, 63 m elevation) when a Kookaburra flew in holding a dead adult (total length ~1.2 m) Brown Tree Snake in its beak, landed ~2 m distant from where she was seated, and dropped the snake (several local Kookaburras are regularly fed by residents of the property, which likely explains willingness of this subject to approach so closely). The carcass was determined as *B. irregularis* on the basis of body habitus, long tail, and dorsal and ventral colour pattern. The Kookaburra repeatedly picked up the carcass with its beak, shook it vigorously, and threw it down on the pavers (Figure 1). It abandoned the carcass, perhaps because it was too large to swallow or too fresh to dismember, and flew off at dusk ~1720 hrs; several Kookaburras were heard calling in the vicinity a few minutes later. Subsequent examination of the carcass revealed the head was missing, the anterior ribs were exposed, the anterior neck was slightly flattened, and the distal third of the tail had been severed during manipulation by the Kookaburra (Figure 2). On the basis of lack of odour and necrosis of the carcass, it was estimated mortality had occurred on the day of observation or the previous night; it was not collected.

## DISCUSSION

There is a dearth of published records of *D. novaeguineae* snake dietary items identified to species. Mann (1933) reported *Austrelaps superbus* (Elapidae) as prey items of *D. novaeguineae* in Victoria. O'Grady (1961) reported a *D. novaeguineae* "attacking" an

adult of another arboreal snake species, *Dendrelaphis punctulatus* (Colubridae: Colubrinae), near Grafton, New South Wales, although from reading it is doubtful that this was an 'attack' on the snake, but rather kleptoparasitism of the "large green frog" prey item, likely *Litoria caerulea* (Salientia: Hyloidea: Pelodyadidae), held by the *D.*

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**Figure 1. *Boiga irregularis* held in the beak of *D. novaeguineae*. Photograph: P.A. Jones.**



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**Figure 2. Abandoned *B. irregularis* carcass on pavers of the verandah. Photograph: P.A. Jones.**





*punctulatus*; this account was also noteworthy for the interpretation that initially, several of two species of smaller birds gathered around the Kookaburra apparently for protection from the snake, and by their agitated behaviour and continuous alarm calls desired the Kookaburra to attack the snake!

*Boiga irregularis* is typically inactive by day, so if predated, the diurnal *D. novaeguineae* in the above account had presumably located it whilst it was coiled in an arboreal refugium, which would indicate high visual acuity and also imply recognition of an inactive prey item by this predator. However, on the basis of the missing head, exposed anterior ribs and the slightly flattened anterior neck of the carcass, it is more probable that this was a case of scavenging, the carcass likely road-killed the previous night, although a neighbour had killed "a snake" in the area prior to observations, and the head was perhaps subsequently removed by a cat, fox, or dog (domestic dogs in Australia often eat the heads of snakes they have killed or found dead, DCM, pers. obs.), and it is possible the Kookaburra had located this carcass. *Boiga irregularis* is common on the property and in the wider region, and a family group of 5-6 Kookaburras occupy a territory that includes the property (pers. obs.), however the above was the only instance of interaction between these taxa observed to date. To our knowledge, this is the first report of predation or scavenging on *B. irregularis* by *D. novaeguineae*. There have been several photographic images showing predation by *D. novaeguineae* on other snake species posted on the internet in recent years, including *Anilius nigrescens* (Typhlopidae), *Dendrelaphis punctulatus* (Colubridae), *Cacophis squamulosus*, *Cryptophis nigrescens*, *Demansia psammophis*, *Pseudechis porphyriacus*, and *Pseudonaja textilis* (Elapidae); we would urge photographers to publish such important observations in herpetological or natural history journals.

## ACKNOWLEDGEMENTS

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# AN OBSERVATION OF LEECH PARASITISM OF *CRINIA SIGNIFERA* (COMMON EASTERN FROGLET)

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The small terrestrial frog *Crinia signifera* is common throughout most of the south-eastern portion of Australia (south-eastern Queensland, eastern New South Wales; the Australian Capital Territory, Victoria, Tasmania, and the south-eastern corner of South Australia). This species generally calls year-round and is found in many habitats, generally in close proximity to water (Cogger, 2018).

On the evening of 28 June 2016, the authors were observing amphibians around a small man-made pond at Wangat Lodge near Dungog, New South Wales, Australia (32°14'42.8"S 151°41'38.8"E, WGS 84). There were many *C. signifera* calling and swimming around the small pond and one individual was sitting amongst reeds at the edge of the water with a leech attached at its

**Figure 1. *Crinia signifera* attacked by leech (possibly *Chtonobdella limbata*) in New South Wales, Australia.**



rear left leg. The authors photographed the frog and its attached leech (Figure 1) before observing it startle and swim out of their sight with the leech still attached.

Australian leeches are understudied and without a specimen it is difficult or nearly impossible to definitively identify this leech. Based on size, general appearance, pattern of the markings, and records for this area the ectoparasite resembles the hematophagous terrestrial leech *Chthonobdella limbata* (Australian Land Leech) or related species.

There are scattered reports of leech predation on frogs at the spawn and tadpole stages of their life cycles and of leech ectoparasitism on adult frogs from many different regions of the world, including Africa, Australia, Europe, and North America. In Europe, at least eight species of frogs in three genera have been preyed on by leeches in the genera *Batrachobdella* (Ayres & Iglesias, 2008), *Helobdella* (Tiberti & Gentilli, 2010) and *Hirudo* (Merilä & Sterner, 2002; Ayres & Iglesias, 2008). In Madagascar, at least four species of frogs in three genera have been preyed on by leeches of the genus *Malagabdella* (Rocha et al., 2012). In Australia and North America, leeches have been shown to not only prey on adult frogs but on immature stages as well. The leech genera *Bassianobdella*, *Desserobdella* and *Macrobdella* have been shown to predate eggs and tadpoles of *Rana* spp. (Berven & Boltz, 2001; Schalk et al., 2002) and *Limnodynastes* spp. (Burgin & Schell, 2005). The impacts of leech predation/ectoparasitism are poorly understood. Stead and Pope (2010) suggested that the Cascades Frog (*Rana cascadae*) may possibly have suffered declines as a result of parasitism on adults and eggs by leeches, but this was only a suggestion and there is little evidence available to indicate if broader impacts actually occur. Some of the leech genera found in the range of this North American frog that possibly contribute to its decline include *Erpobdella*, *Glossiphonia*, *Haemopsis*, *Helobdella*, and *Placobdella* (Stead & Pope, 2010).

The authors were unable to observe if the individual *C. signifera* was killed by its ectoparasite or not. Given the large and

widespread populations of *C. signifera*, it seems unlikely that leeches have a major impact on populations of this frog; it is possible, however, that some leeches are detrimental to amphibians in certain situations.

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# OPPORTUNISTIC FORAGING IN THE KING'S SKINK (*EGERNIA KINGII*)

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## INTRODUCTION

Adult King's Skinks (*Egernia kingii*) are opportunistic omnivores, and their diet includes insects (e.g. earwigs, ants and beetles), spiders, snails, earthworms, shed skin, seabird eggs and plant material (Arena & Wooller, 2003; Brown, 2012). In a study on Penguin Island (Western Australia), Arena and Wooller (2003) found that only five percent of faecal samples from King's Skinks contained plant material alone and seven percent contained only animal material. Vertebrate material discovered in the faecal samples included mice (*Mus musculus*) and other lizards (e.g. *Ctenotus lesueurii*) (Arena & Wooller, 2003). King's Skinks have on several occasions been observed eating eggs from seabirds (Serventy & White, 1943; Tarr, 1949; Lane, 1978; Meathrel & Klomp, 1990; Wooller & Dunlop, 1990) and a newspaper article from 1843 describes a lizard that is very likely to be a King's Skink preying on chicks and older birds (Gilbert, 1843).

In this article, I describe two instances of opportunistic foraging (scavenging a bird carcass and the consumption of a bird dropping (faeces)) that were observed during a study of King's Skink on Penguin Island in 2015 that represent new food items for this species.

## OBSERVATIONS

The study took place between 15 September and 4 December 2015 on Penguin Island (32°18'21"S 115°41'26"E), Western Australia. On 28 October at 12:36 hrs an adult King's Skink (sex unknown) was observed tongue flicking a desiccated bird carcass (possibly a seagull chick based on the size and location of the carcass). The skink subsequently dragged the carcass into dense vegetation. It is unknown whether the skink later consumed it. A video of the observation can be found at the following link (<https://www.youtube.com/watch?v=WLxfclwDJs&feature=youtu.be>)

Over the course of the study, multiple adult King's Skinks were observed tongue flicking bird droppings (faeces) (Figure 1). On 3 December at ca 09:35 hrs an adult King's Skink (sex unknown) was observed tongue flicking two bird droppings and thereafter consuming the later (Figure 2). The bird dropping was swallowed within a few seconds, without much chewing. The consumed bird dropping was approximately 1.5 x 0.5 cm in size and most likely to have come from one of the common seabird species that nest on the island (Bridled Tern (*Onychoprion anaethetus*), Caspian Tern (*Hydroprogne caspia*), Crested Tern (*Thalasseus bergii*), Fairy Tern (*Sternula nereis*) or Silver Gull (*Larus novaehollandiae*)). The event took place on the wooden boardwalks made for tourists and visitors. The trail was raised about 0.5 m above the sand, and the ground dwelling Buff-banded Landrail (*Gallirallus philippensis*) and Little Penguin (*Eudyptula minor*) were only very rarely observed on the raised pathways. The consumed bird dropping appeared to be intact (rather than splattered), making it likely that it was defecated by a bird walking on the boardwalks rather than by a bird flying over the boardwalks.

## DISCUSSION

The frequency of heterospecific coprophagy in lizards is unknown, and only one other observation has been documented. A subadult male Australian Water Dragon (*Intellagama lesueurii*) was observed feeding on faeces from an Australian White Ibis (*Threskiornis molucca*) (Baxter-Gilbert, 2017). This observation of King's Skinks tongue flicking and consuming bird droppings adds to the evidence that lizards may utilize bird droppings as a food resource. While it is likely to be a low-value food resource, its abundance on the island may mean that it can form an available and easy to access food resource.

**Figure 1. Two King's Skinks investigating bird droppings on a boardwalk. At the same time, three Silver Gulls are standing on the boardwalk.**



The video showing a King's Skink dragging a carcass is evidence of how opportunistically these species forage. It is very likely that more detailed and longer-term studies on wild populations of King's Skinks will show that these lizards have a much more varied diet than previously recognized.

These new observations on coprophagy, tongue flicking and scavenging in King's Skink suggest potential disease transmission

pathways not earlier described between bird species and *E. kingii*. For example, seagulls (which are opportunistic foragers) may carry *Salmonella* bacteria, which could be transmitted to other species through contact with droppings or intestinal remains (Tizard, 2004). Different pathogens and parasites may in this way be transmitted from birds to lizards which has implications for the inter-specific transmission of diseases.

**Figure 2. Adult King's Skink close to the bird dropping that it later consumes (marked with arrow).**



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# MALE COMBAT IN THE STRIPED MARSH FROG (*LIMNODYNASTES PERONII*; LIMNODYNASTIDAE)

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The Striped Marsh Frog, *Limnodynastes peronii*, is a common species across much of the coast and ranges of eastern and south-eastern Australia, and frequently persists or even thrives in modified suburban environments, breeding in backyard ponds (Barker & Grigg, 1977; Robinson, 1993; Griffiths 1997; White et al., 2016; Cogger, 2018; Mahony, 2023). Its breeding call, a single "pock" note repeated, often over many hours during day and night, is a familiar sound in such environments, often mistaken for a dripping tap (Mahony, 2023). Despite this, the ecology of the species is remarkably poorly studied.

The species shows strong sexual dimorphism, with males having hypertrophied forearms and the first metacarpal frequently perforating the skin, forming a sharp spine (Moore, 1961; Clyne, 1969; Barker & Grigg, 1977; Martin & Littlejohn, 1981; Sanders, 2021). The function of these features is the subject of debate in the literature. Moore (1961) presumed that they were associated with gripping the female during amplexus, while Schauble (2004) noted that males commonly bore scarring over the head that could be explained if the exposed metacarpal was used in male combat.

I am able to locate only a single previous observation of male combat in this species. Clyne (1967), in a rather anthropomorphised description, reports one instance of male combat initiated by the intrusion of a male into a situation where a resident calling male was being approached by a female. Clyne wrote: "the two males wrestle together in slippery combat, thrusting shoulder to shoulder, chasing about under the overhanging rocks to emerge and press throat to throat, chin to chin, with snouts pointing skywards and limbs

ineffectually grappling for a hold. Now they pause, gazing over each other's shoulders as though indifferent; now they break away to resume the rough and tumble, groaning and clucking the while. For half an hour or more they argue, then down they suddenly dive in a chase through the deep water, legs thrust out behind to their full extent, giving them quite a turn of speed. The female, still in the vicinity, goes on staring at the wall . . . One of the males surfaces. In a flash he is back in position, almost throwing himself over backwards as he inflates his throat and resumes the earlier rhythmic calling. He is the original territory-holder, identifiable by a graze on his head."

On 26 March 2017, at about 2100hrs, I observed and photographed male combat in *L. peronii* in a water-filled ceramic bowl about 1 m in diameter and 50-60 cm deep and planted with aquatic plants in a backyard in St Ives, Sydney. The bowl was adjacent to a swimming pool that had been converted to a pond, similarly planted with aquatic plants. Both frogs were identified as male by the hypertrophied forearms and yellow throats. The frogs had commenced wrestling when I first noticed the activity, drawn by the sound of splashing and unusual vocalisations (similar to Clyne's description of "groaning and clucking"), so it is not sure how much was missed, but my observations continued for about 20 minutes. During that time, a series of photographs was taken. After deleting a few that were out of focus, 130 images remained and were the basis for the following descriptive sequence.

At the time of the first photograph, the frogs were pushing against each other, their snouts to the right of the other frog's snout, and front limbs overlapping. This was followed by one

frog (hereafter Frog A) being flipped upside down, then Frog B lying transversely in front of Frog A before Frog A climbed onto the back of Frog B, adopting a position similar to amplexus (Figure 1 [image #4]), then returning to the initial position, facing each other with snouts to the right of each other (Figure 2 [image #7]). Frog B then lay transverse to the front of Frog A with Frog A's snout over Frog B's body. A grapple then followed with front limbs interlocked and throats tilted up and pressed against each other. The frogs returned to a face-to-face position, snouts to the left of each other before grappling again with snouts raised (Figure 3 [image #18]). At the next break, the frogs lay at right angles to each other, snout-to snout (Figure 4 [image #30]) before Frog A advanced to a transverse position in front of Frog B, with the latter's snout on the former's back. Another grapple followed, in which the frogs appeared to be attempting to flip each other over, then Frog B lay transverse to Frog A, with the latter's snout on the former's back (Figure 5 [image #34]). During the next grapple, both frogs fell side on to the water surface (Figure 6 [image #36]) before returning to the upright position, throats raised and pressed against each other. Afterwards, Frog B again lay transverse to the front of Frog A before grappling again, once more attempting to flip each other over. Immediately following this next grapple, the frogs lay alongside each other facing in opposite directions, then returned to facing each other, snouts to the left of the other before grappling again. Frog B then again lay transverse in front of Frog A, then side by side facing in opposite directions, then another grapple occurred. In the next cycle, Frog B lay transverse to Frog A with the latter's snout on the former's back. They then faced each other (snouts to the right side), then Frog B again lay transverse to Frog A before another grapple (Figure 7 [image #110]). This was followed by another cycle of facing each other, snouts to the right, grapple, lying side by side, and another grapple. The wrestling bout ceased when one of the frogs (I am uncertain which) gave up

and fled the scene.

Throughout, it was evident that Frog A was attempting to raise its snout higher than Frog B's or to lie with its head atop Frog B's body. At times this was escalated to the point that Frog A attempted to push Frog B underwater.

The wrestling bouts observed here concur with the brief descriptions provided by Clyne (1967), including the vocalisations, repeated cycles of grappling over a long period, the raised throats pressing against each other during the bouts, and the intervening periods with the frogs seemingly peering over each other's shoulders, although other non-combat positions were noted. These included: one frog side on in front of the other, with or without the snout covering the back of the other; frogs parallel to each other but facing in opposite directions; one on the back of the other, and frogs at right angles to each other with the snouts apposed.

Both Frog A and Frog B showed extensive transverse scratched scarring across the body at the level of the shoulders (Figure 8 [image #116]). However, in none of the grappling bouts observed did the limbs of one frog appear to grip or scratch across this region on the other. Instead, the front limbs usually interlocked alongside and ventral to their bodies, with one exception where one limb of Frog A lay over the mid-dorsum of Frog B, possibly with the first metacarpal pushing into the skin (Figure 7). However, the presence of scarring on the dorsum of males does support the view that male combat produces the scarring, and hence that the hypertrophied front limbs and bony spur on the first finger may be features associated with combat (Schäuble, 2004), although I cannot exclude the possibility that they also facilitate amplexus.

Male combat has also been recorded in two other *Limnodynastes* species, *L. dorsalis* and *L. interioris* (Bush, 1984; Bulbert *et al.*, 2005). Both are members of the *L. dorsalis* species group. Phylogenetic studies by Schäuble *et al.* (2000) using two mitochondrial loci identified

**Figure 1. Frog A on back of Frog B.**



**Figure 2. Frog A (on left) facing Frog B.**





**Figure 3. Frogs grappling, with snouts raised and pressed against each other.**



**Figure 4. Frogs between grapples, lying at right angle to each other.**



**Figure 5. Frog B transverse to Frog A, the latter's snout over the former's back.**



**Figure 6. Grappling, both frogs side-on in the water.**





**Figure 7. Grappling, Frog A with left arm over Frog B.**



**Figure 8. Transverse scarring over shoulders of both frogs.**





*L. peronii* as the sister-taxon to the *L. dorsalis* species group, although Frost *et al.* (2006), with lesser sampling of the species in the genus, but a larger number of mitochondrial and nuclear genes, recovered *L. peronii* as sister to the *L. tasmaniensis* species group, with the *L. dorsalis* group more distant. Hence, it remains unclear how widely male combat occurs in *Limnodynastes*. Among other limnodynastine frogs, combat has been studied in *Adelotus* (Katsikaros & Shine, 1997), and there are reports of scratching on the dorsum and lateral surfaces in male *Heleioporus australiacus* suggestive of male combat (Mahony *et al.*, 2021), but I am unable to find any record of it being reported in *Neobatrachus*, *Notaden*, *Philoria* or *Platyplectrum*.

In both *L. dorsalis* and *L. interioris*, male combat has been hypothesised to be due to defence of calling sites. However, during the period of observation of *L. peronii*, the vocal sacs were not inflated, although whether one or both males were calling prior to the interactions is not known. Unlike the observations by Clyne (1967), no female was noted nearby. Hence, it is not known what initiated the combat, other than presumed territorial defence, as *L. peronii* males are known to call for long periods, initially from under cover on land, then moving to ponds for amplexus and nest building (Barker & Grigg, 1977; Robinson, 1993; Anstis, 2013; Clemann & Swan, 2023), so the possibility of defence of calling sites in the water should be explored in future observations.

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# NESTING OBSERVATIONS OF RADIO-TRACKED WOMA PYTHONS (*ASPIDITES RAMSAYI*) IN SOUTHERN QUEENSLAND

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## ABSTRACT

Activity is rarely observed and recorded for snake that incubate eggs underground. Two wild female Woma Pythons nested in underground burrow systems from early December 2011 to early February 2012 during an intensive radio-tracking program in the Southern Brigalow Belt, Queensland. Neither nesting attempt was ultimately successful due to strong La Niña conditions which caused an extended period of cool and overcast weather in December and an extreme and prolonged flood event at the start of February. During incubation, the nesting females demonstrated maternal care and thermoregulatory patterns that are typical of brooding pythons. Shivering thermogenesis was not detected. Brooding females appeared to actively defend their nest burrows against egg predators. Both nests were scavenged by Lace Monitors after they were abandoned. These observations demonstrate that underground burrows are a critical nesting resource for the Woma Python.

## INTRODUCTION

Despite ever-increasing advances in technological capabilities, it remains notoriously challenging to observe and understand the ecology and life history of secretive animals that spend much of their time underground. Snakes are well-adapted to life in underground burrows, where they are protected from extreme temperatures (e.g. Burger *et al.*, 1988; Bruton *et al.*, 2014) and they can access suitable conditions for incubating eggs (Burger & Zappalorti, 1991). Although some

snakes are known to actively incubate their eggs underground (Alexander, 2007; Mori *et al.*, 2010), this behaviour is poorly understood.

The Woma Python (*Aspidites ramsayi*) is an elusive species with a widespread distribution across arid and semi-arid central Australia. Its range includes Western Australia (WA), southern parts of the Northern Territory (NT) and Queensland (Qld), northern South Australia (SA), and far northwest New South Wales (NSW). Little was known about Woma Pythons in the wild prior to interviews with Traditional Owners in the western and central deserts of WA and the NT (Pearson, 1993), opportunistic radio-tracking of a few individuals over several years in WA (David Pearson, pers. comm.), four months radio-tracking ten adult captive-released adults in SA (Read *et al.*, 2011), and an intensive program radio-tracking twelve wild individuals in southern Qld (Bruton, 2013; Bruton *et al.*, 2014). These programs confirmed the Woma Python is a secretive species that is rarely observable; it usually shelters underground. However, the nesting habitat and habits of wild Woma Pythons were unrecorded prior to this study.

The Woma Python was uncommon in zoos and private herpetological collections until it was bred in captivity in the mid to late 1990s (Kraus, 1995). It is now common in the private captive market in Australia and overseas. Captive females lay, then coil around, a cohesive clutch of 5-20 eggs (12-16 in the wild: Shine & Slip, 1990). However, the egg mass is typically removed and artificially incu-



bated to maximise hatching success (e.g. Spinner, 2014). As such, there are few recorded observations of nesting Woma Pythons in captivity.

MATERIALS AND METHODS

Five female and seven male Woma Pythons were surgically implanted with Holohil SI-2T (11 g) temperature-sensitive transmitters during an intensive radio-tracking program in southern Queensland from October 2010 to May 2012. Each python was radio-tracked every ~55 hours for approximately one year and most of the pythons were tracked simultaneously from May 2011 to March 2012 (see Bruton, 2013 and Bruton *et al.*, 2014 for further details).

Great care was taken to stealthily approach each individual during the radio-tracking program, to increase the likelihood of observing undisturbed activity (see Bruton, 2013). Position, distance moved, body temperature, ambient conditions, habitat attributes, and general field notes were all recorded each time a Woma Python was tracked. Flagging tape was used to mark shelter sites and to monitor distances moved within shelters. To

monitor underground movements within shallow burrow systems, flagging tape was tied to robust clumps of grass where the signal was strongest on the surface.

Nesting confirmation

In November 2011, two of the five female Woma Pythons significantly reduced their movement distances compared to the other ten radio-tracked pythons (Table 1). This is a hot time of the year when Woma Pythons are generally active. The two nesting females were confined to a single underground burrow system each from the start of December 2011. Movement within their respective burrows was reduced to < 1 m horizontal displacement as measured on the surface. In contrast, the other ten Woma Pythons – including three non-reproductive females – continued to regularly move distances of > 300 m among shelter and feeding sites (Table 1).

Nesting Woma Python 'LL' was observed with a distended posterior body on 27 November 2011. She was observed five days later (on 2 December) without a distended posterior body, indicating that she had oviposited in the

**Table 1: Average movement distances between shelters for nesting Woma Pythons ('WN' and 'LL') and non-nesting Woma Pythons during the pre-oviposition and nesting periods from 2 Nov 2011–31 Jan 2012. Movements of 10 non-nesting Woma Pythons were averaged for each individual prior to determining the mean. Error values are standard error.**

Monitoring period	Nesting Woma Pythons		Average of 10 non-nesting Woma Pythons (male and female)
	Woma 'LL'	Woma 'WN'	
Pre-oviposition: November 2011	113 ± 50 m	95 ± 0 m	426 ± 76 m (avg. range: 170-762 m)
Nesting: December and early January 2011	0 m (0.3 ± 0.1 m in burrow)	0 m (0.3 ± 0.1 m in burrow)	309 ± 63 m (avg. range: 105-512 m)
Only woma 'LL' nesting: Mid-late January 2012	0 m (0.7 ± 0.4 m in burrow)	183 ± 93 m	490 ± 172m (avg. range: 200-1303 m)

interim. Nesting Woma Python 'WN' was not observable from 1 September 2011 until 4 February 2012, which is not unusual for this secretive species (Bruton *et al.*, 2014). Her inferred oviposition period is also the first week of December based on a significant reduction in horizontal movement within her underground burrow system. These inferred oviposition timings are consistent with dissected museum specimens of Australian pythons – including the Woma Python – having enlarged ovarian follicles or oviductal eggs from October to January (Shine & Slip, 1990).

### Nest monitoring

Each of the nesting Woma Pythons continued to be tracked approximately every 55 hours as part of the ongoing radio-tracking program. A Scoutguard 550BV remote camera was deployed to monitor activity at the main entrance to each of the underground nests. One nest was observed continuously from early November 2011 (prior to oviposition) until it was abandoned in early January 2012 and the second nest was observed continuously from early January until it was abandoned in early February 2012. A Titley RF automated data logger powered by a solar panel and car battery recorded body temperature continuously whenever a Woma Python was in range and the receiver was able to draw power. This was positioned to prioritise body temperature logging for the two nesting Woma Pythons from early December 2011 until early February 2012.

## RESULTS AND DISCUSSION

These are the first recorded observations of Woma Pythons attempting to nest in the wild. Two females attempted to nest for 40 and 60 days respectively. Although neither nest was successful, these attempts provide significant insight into the behaviour, physiology, and requirements of nesting Woma Pythons in the wild. They contribute to a general understanding of nesting behaviour in cryptic snakes.

### Nesting frequency

Two of the five radio-tracked woma pythons nested during this study. It is presumed that both females mated prior to being implanted with transmitters in June 2011. Woma Pythons have been sighted following each other tail-to-nose at the study site in April (Danny Wilkinson, pers. comm.) and they usually mate in captivity in April or May after a cooling down period. The largest female Woma Python in this study did not nest despite briefly co-habiting in underground burrow systems with two mature radio-tracked males during the 2011 mating season. This is not unusual given female pythons and boas rarely breed every year (e.g. Shine & Madsen, 1997; Alexander, 2007; Chiaraviglio & Bertona, 2007). The other two females were the smallest individuals that were radio-tracked, at 1.25 m & 1.35 m snout-vent-length. This is approximately the size when females reach sexual maturity (Shine & Slip, 1990). They may not have been sexually mature during the 2011 mating season.

### Nest sites

The underground burrow systems that were used for nesting in this study consisted of shallow (usually < 0.5 m deep) interconnected tunnels with multiple entries. These entries were not much larger than the diameter of an adult Woma Python and they were located several metres apart on the surface. These underground burrow systems provide the most stable thermal conditions within the landscape, buffering inhabitants from ambient temperatures that are lethal (Bruton *et al.* 2014). The small size and number of surface entries may also limit airflow and retain high levels of humidity, allowing nesting pythons to regularly leave the egg clutch to bask (Stahlschmidt & De Nardo, 2010) and maintain a high body and nest temperature (Alexander, 2007).

One of the nesting burrow systems was investigated after egg incubation ceased. This underground burrow system was mapped

using a burrow scope and flagged Woma Python positions (Figure 1). The presumed nesting chamber – below the strongest and most consistent signal above-ground from the nesting female – was a three-way intersection of tunnels that was approximately 0.5 m below ground level and 4 m from the nearest surface entry along a curved tunnel. No eggs or shells were detected in this chamber or adjoining tunnels despite an extensive search. It is assumed they were all scavenged after the nest was abandoned (see Figure 2 and discussion below).

### Nesting failure

Woma Python eggs typically take 60-75 days to hatch in captivity, with a longer incubation period required at cooler temperatures (Kraus, 1995; Kelsey Engle, Australia Zoo 2012, pers. comm.). Nesting Woma Python 'WN' abandoned her nest in early January, approximately 40 days after presumed oviposition. Camera monitoring showed the abandoned nest was immediately scavenged by five different Lace Monitors (*Varanus varius*) (Figure 2). Unusually wet and cool conditions at the study site in late 2011 may have prevented 'WN' from attaining sufficiently high body temperatures by basking to enable her eggs to successfully develop (see Alexander, 2007 for a discussion about thermally limiting days for the African Python).

Strong La Niña conditions resulted in extreme flooding at the study site at the start of Febru-

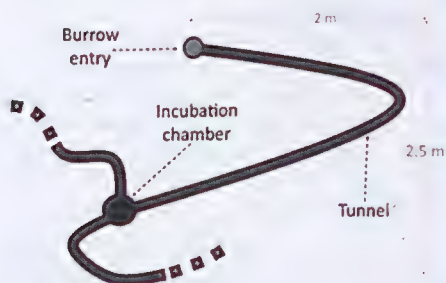
ary 2012 (Pritchard, 2013). The underground nesting burrow system of Woma Python 'LL' was completely inundated for at least 24 hours, approximately 60 days after egg incubation commenced. She was observed in the flooded entry to the burrow system (Figure 2) but she had departed the burrow system two days later. Camera detections show that at least two different Lace Monitors excavated the main entry to the saturated burrow system within that period (Figure 2). It was not possible to investigate this burrow system due to saturated soil conditions. It is unlikely that the egg clutch hatched prior to the flood due to: 1) cool temperatures in December 2011 extending the incubation period, and 2) the presence of scavenging Lace Monitors immediately after the flood. Lace Monitors were not detected digging into underground burrows at any other location during the radio-tracking program except at the other abandoned nest.

Failed nesting may have been widespread among Woma Pythons in southern Queensland during the 2011-2012 nesting season due to cool conditions in late 2011 prolonging the incubation period, and the extent of extreme flooding across the region in early 2012 (Pritchard, 2013).

### Nest protection

Camera monitoring indicated that incubating Woma Pythons may deter egg predators from

**Figure 1. Aerial schematic of an underground Woma Python nest (left) and investigating the egg chamber with a burrow scope (right).**





**Figure 2. Two of five different Lace Monitors scavenging eggs from the abandoned nest of Woma Python 'WN' (top). Brooding Woma Python 'LL' submerged in her flooded underground nesting burrow system (bottom left) and one of two Lace Monitors detected scavenging the same nest immediately after the flood (bottom right).**



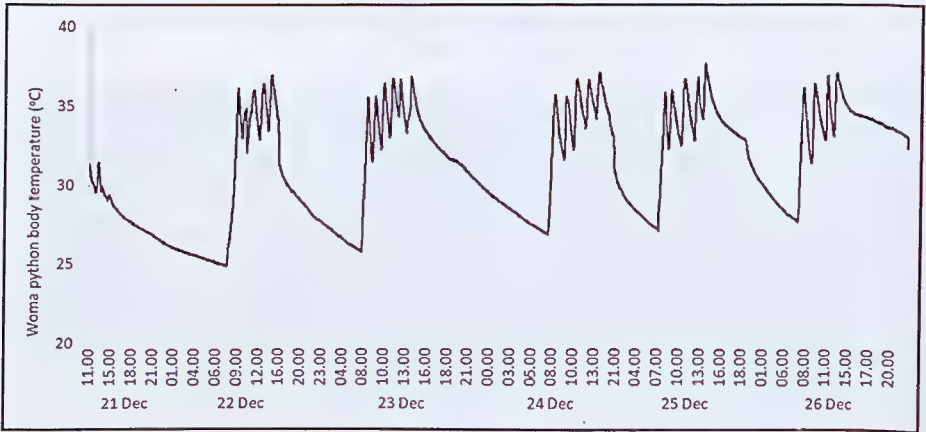
underground nests while they are brooding. Nest protection is rarely documented in snakes, except for cobras (*Naja* spp.) (Oliver, 1956; Campbell & Quinn, 1975). Woma Pythons are effective predators within confined spaces (Fyfe & Harvey, 1981; Bruton 2013) as well as in exposed areas (Bruton, 2013). Several Lace Monitors and Sand Goannas (*V. gouldii*) were detected investigating and entering an underground burrow system 2-3 weeks prior to the approximate time of oviposition for one of the nesting Woma Pythons. Sand Goannas are a common prey item for Woma Pythons at the study site (Bruton, 2013) and adult Lace Monitors are approximately the same size as adult Sand Goannas in this area: they also risk predation by a nesting Woma Python. Following oviposition, Sand Goannas and Lace Moni-

tors continued to be detected on camera near the nesting burrow, but they did not enter or approach the entry. However, after each of the nests was abandoned, it was immediately scavenged by multiple Lace Monitors (Figure 2). Sand Goannas were not detected on camera scavenging at these nests despite being more common at the study site (Bruton et al., 2013).

### **Thermoregulation**

The automated body temperature logger recorded sporadically during the egg incubation period, mostly during fine and clear conditions. Several multi-day periods of almost continuous recordings show the nesting Woma Pythons maintained a high diurnal body temperature of 31-37°C by basking 4-

**Figure 3. Typical daily body temperature pattern for an incubating Woma Python.**



6 times per day, with body temperature decreasing to 25–28°C overnight (Figure 3). These body temperature patterns show the nesting females engaged in regular periods of basking away from the eggs, with each basking event followed by a drop in body temperature as she released heat to the egg cluster within the underground nest chamber (Figure 3). Frequent basking to maintain a high and constant clutch temperature is a common brooding strategy among pythons (Tryon & Whitehead, 1988; Shine *et al.*, 1997; Alexander, 2018). The body temperature of the nesting Woma Pythons gradually decreased overnight (Figure 3) indicating they did not engage in shivering thermogenesis while monitored (see Harlow & Grigg, 1984; Shine *et al.*, 1997; Pearson *et al.*, 2003; Ramesh & Bhupathy, 2010).

### Importance of underground burrows

Pythons actively select nest sites with optimal humidity and temperature conditions to ensure incubation is successful (Stahlschmidt *et al.*, 2011). Underground burrow systems provide nesting Woma Pythons with suitable conditions for incubating their eggs, and protecting the egg clutch and the incubating female from predators. The use of these underground burrow systems for egg incuba-

tion during hot summer months complements the exclusive use of this shelter type by all radio-tracked Woma Pythons at the study site during cool winter months to avoid lethal temperatures (Bruton *et al.*, 2014). These underground burrows are a critical habitat attribute for this species. Yet the genesis and stability of this critical habitat resource in this area is unknown (see Bruton *et al.*, 2014 for discussion).

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## ETHICS STATEMENT

All procedures were approved by The University of Queensland Animal Ethics Committee (GPEM/187/10) and the Queensland Environment Protection Agency (WISP07547310).

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# KEEPING AND BREEDING THE PILBARA DEATH ADDER (*ACANTHOPHIS WELLSI*) IN CAPTIVITY

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## INTRODUCTION

The Pilbara Death Adder (*Acanthophis wellsi*), previously considered part of the Desert Death Adder (*Acanthophis pyrrhus*), is a recently recognised species widespread the Pilbara region of Western Australia, with an isolated population occurring on the Cape Range Peninsula; the intervening area between the Pilbara and Cape Range is occupied by hybrids between *A. wellsi* and *A. pyrrhus* (Aplin & Donnellan, 1999). *Acanthophis wellsi* exhibits a prominent pattern polymorphism, with two main, naturally occurring colour varieties: pale banded individuals, often referred to as 'typical', and black-headed, black-banded individuals, frequently referred to as 'melanistic', with occasional other variants, including a rarer 'weakly banded' form (Aplin & Donnellan, 1999). The species remains poorly known ecologically. Shine *et al.* (2014) reported frogs, lizards, birds and mammals from the stomachs of museum specimens, a mean litter size of 8.5, and adult females attaining larger body sizes than adult males.

After keeping and breeding the Pilbara Death Adder (*Acanthophis wellsi*) for the best part of the past decade, and witnessing this species thrive in captivity, I document some of my practices and findings on this Australian elapid, including details of two cases of reproduction from the 2018/19 breeding season.

## ACQUISITION OF INITIAL STOCK

My initial trio, two males and one female, were wild-caught under permit from the vicinity of Pannawonica, on the western edge of the Hamersley Range in the Pilbara. The two males were obtained in January 2011, and the female in November 2011. After a period of quarantine, the males were freighted to

Queensland on 1 July 2011 and subsequently brought into my collection. The female was also quarantined after capture and freighted on 27 May 2012. All three represented the melanistic variety.

Upon arrival, each animal was again quarantined for a period of three months. This may seem excessive, but because the animals were shipped from another private collection, it was considered appropriate to minimise the risk of spreading potential disease to an established collection (Rossi & Rossi, 2009).

Previously, these three foundation individuals had no health problems. However, upon bringing wild-caught *A. wellsi* into captivity, it was not only prudent but a mandatory requirement of what is now the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) to treat them for internal parasites. While wild reptiles typically harbour a wide variety of parasites and may live predominantly unaffected, when brought into a captive environment, parasites are presented an opportunity to overwhelm the host, potentially through reduced immune response due to the stresses of captivity (Weigel, 2000; Klingenberg, 2007). Accordingly, the first three snakes were each medicated with a single dose of Metronidazole (Flagyl suspension) at a dose rate of 1 ml/kg. This was given orally by injecting it directly into a thawed mouse: Vetafarm Wormout Gel (1 ml/kg) was also injected into the mouse, and repeated 14 days later. Metronidazole is contraindicated for debilitated specimens; gravid individuals, and animals with hepatic (liver) dysfunction (Klingenberg, 2007).

## HOUSING

All *A. wellsi*, both the original trio and subsequent offspring, are housed in a clinical style

of enclosure, which is the preferred option for many keepers (Cooper & Williams, 1995), as opposed to the pseudo-natural style that others opt for.

Adults are individually kept in transparent plastic tubs measuring approximately 55 (L) x 37 (W) x 21 cm (H). These dimensions are similar to those used by Hoser (1987) for the Common Death Adder (*Acanthophis antarcticus*). Enclosure furnishings are simple, readily available and hygienic, with newspaper provided as the substrate. A recyclable plastic container is used for a water bowl, and an appropriately sized cardboard box for a hide, both located at the cool end of the enclosure. Water is changed at regular intervals, usually weekly, or immediately if fouled. Some loose sheets of paper towel are placed at the heated end of the enclosure. These create a microhabitat that allows the snake to thermoregulate more effectively, and the snakes are regularly observed buried underneath or between them. Ventilation is provided via evenly distributed 0.7 cm air-holes in the lid. The lids possess dual hinging clips which ensure a safe and compact fit.

Neonates are immediately separated from the mother after emerging from their embryonic sacs, and individually housed in transparent plastic tubs approximately 25 (L) x 23 (W) x 12 cm (H). The substrate supplied is paper towel which, like newspaper, is hygienic and prevents impactions to the digestive tract as it is not readily ingested (Eipper, 2012). Two hides are provided in each of these enclosures, created from a paper cup cut in half lengthwise—one half is placed on the heat and the other half at the cool end. A water bowl of the same style but smaller in size than those in the adult enclosures is also located at the cool end. Ventilation is supplied by smaller 0.4 cm air holes. These tubs have lids that possess secure, quad hinging clips.

Once individuals reach about 12 months of age, they are transferred into the same design of plastic tub but of intermediate size, approximately 35 (L) x 23 (W) x 12 cm (H). Paper towel is used as the substrate, and a

hide box and water bowl (the same sizes and styles as those in the adult tubs) are placed at the cool end. The paper towel is deliberately torn off about one third longer than the length of the enclosure, and the extra length folded over tightly to create a flap, acting as another hide at the warm end of the enclosure. The style of lid and ventilation are identical to that of the neonates. Typically, snakes are kept in these tubs until they reach around 24 months of age, or a near-adult size, at which time they are transferred into their adult enclosures where they then remain.

Because all *A. wellsi* are kept in tubs that are heated from below, it is critical to select enclosures that have a completely flat base to ensure minimal heat loss.

## HEATING AND LIGHTING

Heating is one of the most fundamental aspects of husbandry when maintaining Death Adders, and this cannot be underestimated, particularly regarding neonates and juveniles (see also Hoser, 2004). The intensity of heat supplied and appropriate thermal gradient are critical. Seasonal changes in temperature reflecting the variation in their natural habitat has long been recommended as vital to stimulating breeding (Mader, 2005). My experience has been that *A. wellsi* respond better when given access to higher temperatures than some literature on Death Adder husbandry suggests. For instance, Eipper (2012) proposes that they should be maintained at approximately 24°C at the cool end and 32°C under the basking light. However, I had significantly more success raising young snakes once temperatures were increased.

All *A. wellsi* are supplied underfloor heating that facilitates their natural behaviour due to their terrestrial and nocturnal activity patterns (Bush & Maryan, 2011).

Adults are heated at one end of the enclosure by two or three strips of heat cord depending on the season (two in summer and three in winter). A thermostat is set and kept at the cool end of the enclosure, and when the air



temperature well above the substrate reaches 30°C, all heating is automatically switched off. To further reduce the risk of overheating in summer on very hot days, a central air-conditioner is in daily operation in the room throughout the warmer months. Snakes are frequently seen positioned in the transition zone between the two ends of their enclosures, rather than spending much time directly on the hot spot. This arrangement has also been successfully used by Hoser (2004), with the same behaviour displayed by the animals. It is imperative to ensure the ambient temperature remains appropriate to create a safe and suitable thermal gradient.

Over the course of a year, the substrate temperatures in the enclosures of the four 2018/19 breeders were monitored. In summer, the hot spot ranged from a 32.2–45.1°C, with an average of 35.8°C, while the temperature at the cool end ranged from 22.1–32.7°C, with an average of 29.0°C. In winter, the hot spot fluctuated between 28.8–39.9°C, with a daily average of 34.5°C while the cool end ranged from 11.6–26.3°C, with a daily average of 24.2°C. Intermediate temperatures were recorded in autumn and spring. Minimum ambient temperature in winter on the Gold Coast where the snakes are being kept is close to (within 1.0°C) the temperature at Pannawonica (Bureau of Meteorology, 2020). Under this thermal regime, I have had successful propagation with every attempt to pair *A. wellsi*.

All younger *A. wellsi* are provided heating using heat mats, which occupy one-third of the space under each tub. The mats distribute a broader, more even heat to the substrate surface than the cord used for adults, which seems to facilitate digestion and improve general health in neonates and juveniles, especially in winter months. As for adults, the temperature cut off is set at 30°C at the cooler end of the enclosure, allowing for higher temperatures at the hot spot. Young snakes are on occasions seen warming on the hot spot even at >35°C, something rarely seen with adult snakes.

As *A. wellsi* is nocturnal, the only lighting provided is through a central fluorescent globe located in the middle of the room's ceiling, but this does not contribute to heating. It is, however, essential to ensure a natural photoperiod regime is maintained, as Eipper (2012) expressed. Thus, I routinely manually turn the fluorescent globe on each morning not long after the sun comes up and turn it off shortly after the sun goes down.

## CLEANING

Snakes are removed prior to the commencement of any cleaning and placed into temporary holding bins. Spot cleans are routinely performed, with any enclosure décor disposed of and replaced when required, i.e. if it becomes wet or soiled.

Regular enclosure disinfection takes place every two to three months for adults, and every month for neonates and juveniles as these younger animals have a higher feeding and defecation frequency. All enclosure furnishings are discarded. Methylated spirits and water (1:1 ratio) in a spray bottle is used to clean the entire enclosure. I find this mixture useful for the removal of urate and faecal remnants that may have stuck to the tub. Once the enclosure has been completely dried with paper towel, F10 Super Concentrated (SC) Veterinary Disinfectant (1:125 ratio, as recommended by Fry *et al.*, 2015) is liberally applied to the enclosure interior, left for at least 15 minutes, then wiped down with paper towel, or alternatively, simply left to air dry. Following the disinfection process, new enclosure furnishings are introduced, then the animals placed back in the enclosure. All equipment (e.g., hooks, forceps, holding bins) is also frequently disinfected using F10 SC (Fry *et al.*, 2015). Temporary holding bags (pillowslips) are washed after use.

## FEEDING

*Acanthophis wellsi* are reliably voracious feeders in captivity. My snakes are all fed on commercially sourced thawed mice, commensurate with body size and the snake's

ability to consume larger prey items. Unless preparing an animal for breeding, I am an advocate of keeping all species of captive snake lean. Adult *A. wellsi* are typically fed every 2-3 weeks. However, neonates and juveniles are consistently fed weekly until they reach 12 months of age. Specimens are then fed fortnightly until approximately 24 months, when they are transferred onto the adult feeding regime. These feeding frequencies are similar to those recommended for *Acanthophis* by Fry *et al.* (2015). This is done to keep the snakes healthy, as overfeeding can result in a high metabolic rate, contributing to a reduction in longevity, as well as fatty infiltration of organs, often seen in overweight captive snakes (Mader, 2005).

Although *A. wellsi* naturally eat a varied diet consisting of ectotherms and endotherms, *Acanthophis* species show an ontogenetic shift in diet, with larger individuals eating more endotherms than smaller ones (Shine *et al.*, 2014). This may be one reason why some neonates prove difficult to get voluntarily feeding on rodents. I have found that every *A. wellsi* litter includes individuals that refuse to voluntarily accept mice from the outset. Furthermore, as neonates lose condition quickly, intervention by way of force-feeding is immediately required to ensure the animal does not perish. For the two litters described in this paper, the condition lost by the neonates in the period between birth and their first slough was recorded. Pooling the two litters, neonates lost an average of 0.63 g, or 14.2% of condition (range 0.37-0.89 g), in an average of just 8.6 days (6-10) post-birth ( $n = 16$ ).

For neonate food size, I have found it best to err on the side of caution by feeding prey that is much smaller than the snake is most likely capable of ingesting (see also Hoser, 2003). Newborn mice (pinkies) small enough for this often cannot be sourced. In these circumstances, thawed adult mouse legs are amputated, skinned and used. However, I only endorse this practice as a last resort and if extreme care is taken to ensure no sharp bone edges are present that may lacerate the

tissues of the mouth or gut—this requires time, patience and meticulous care on the part of the keeper.

Force-feeding is carried out by gently pinning the snake and restraining its head with a two-fingered grip behind its jaws. The animal is kept on a flat surface, with my remaining fingers and palm constraining its body. The head of the food item is dipped in water to make it more slippery before suitably sized forceps are used to hold the food item at the snake's mouth, encouraging it to bite onto the head. Invariably, this is easy and is followed by careful and incremental manipulation of the food into the snake's oesophagus. I then gently palpate the food item with my thumb from the head of the snake until it has reached the base of the stomach, discouraging regurgitation.

Extreme care is required when restraining the head of *A. wellsi*. Not only do *Acanthophis* possess the fastest strike and longer fangs than most other Australian elapids, they also exhibit a greater rotational capacity (substantial fang mobility) than any other Australian snake species, providing a more effective biting mechanism (Mirtschin *et al.*, 2017).

The next stage between force-feeding and voluntary feeding is 'tease-feeding', where the young snake is stimulated to eat by encouraging it to bite the food item. For this, I hold the food item with forceps while agitating and encouraging the snake to bite it by a rubbing and tapping motion over the snake's body. This usually does not take more than a minute or two initially, and the time will be reduced over what is typically months (though there are exceptions), until it voluntarily strikes at the food source and consumes it without the need for 'teasing'.

The faster the young snake progresses from force-feeding to tease-feeding, and then to voluntary feeding, the more rapidly the snake grows.

It is completely normal for *A. wellsi* to abstain from feeding for short periods for various reasons (e.g. climate, ecdysis, breeding, etc.).

It is when the cessation of feeding is inexplicable and prolonged that there is an issue. Notwithstanding this, in all the years keeping this species I have never had an established feeder refuse food for unknown reasons, and once a neonate has eaten voluntarily, it invariably does so from that point on, as can be seen in Figure 1. Similar observations for other Death Adder species have been made by Hoser (2003).

Death Adders are commonly characterised as ambush predators that attract prey by use of their caudal lure, and I have observed that caudal luring is more prevalent in neonates, juveniles and subadults than in full-sized adult *A. wellsi*. Hagman *et al.* (2008), working with the Northern Death Adder (*Acanthophis praelongus*), found that dietary range, as well as ontogenetic changes in that composition, depends upon both lure characteristics and prey responses. Caudal luring was essential in drawing lizards within striking range, and smaller lures were more effective at eliciting prey to approach than larger ones. Individual specimens also varied in luring behaviour, and the type of lure movement affected rates and duration of luring bouts.

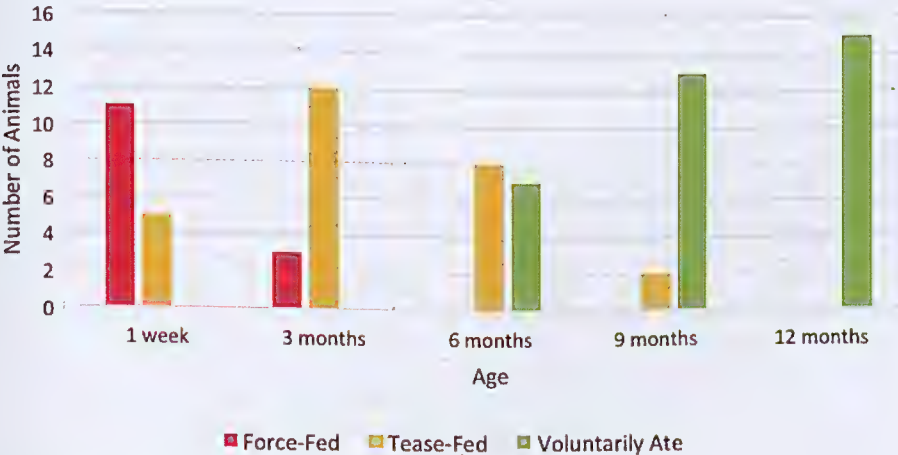
Hence, Hagman *et al.* (2008) proposed a link between these observations and why juveniles appear to caudal lure more often than older and larger conspecifics.

I have observed cannibalism in *A. wellsi* on one occasion. While my juvenile snakes are held in individual enclosures, on one occasion two neonates were initially held together, in an intermediate-style tub with more than double the hide boxes usually supplied. Both animals were removed for feeding and fed (force-fed) independently as well as being kept separate for several hours after their respective meals. During the third week post-birth, one snake had eaten its sibling, and only being capable of consuming half its intended meal, this incident ended in death for both animals. Cannibalism has not been widely documented in Death Adders, except for *A. pyrrhus* where it is particularly prevalent in young individuals (Hoser, 1995).

SLOUGHING

Elapids usually shed their outer keratinised layer of epidermis as a single piece (Banks, 1985). Younger Death Adders have been reported to have a much higher shedding fre-

**Figure 1. Feeding methods (0-12 months) for two litters from the 2018/19 season recorded quarterly from their birth. Total number of specimens reduced by one at 3 months and beyond due to the death of specimen P2:1 on 14 May 2019.**





quency. Hoser (1982) states that wild *Acanthophis* generally shed around 4-5 times per year until approximately 24 months of age. Shedding frequency then steadily decreases until sexual maturity is reached, after which time it remains stable. For my *A. wellsi*, mean shedding frequency from the two 2018/19 litters combined was 6.5 over the course of their first 12 months. The difference may be due to animals in the wild not having the growth rate of captive animals, primarily due to food availability and thermal stress (Johnston, 1987).

I have seldom had an adult *A. wellsi* shed poorly (dysecdysis). The most common causes of dysecdysis in captivity are either from the specimen being dehydrated or maintained in an environment lacking appropriate humidity, which is why it is a more prevalent occurrence in winter months when the air is drier (Eipper, 2012). Since keeping this species, I can only recall one or two occasions where an adult specimen has required assistance with shedding. However, dysecdysis is more common in neonates, and when dealing with a high number of snakes it is inevitable that sooner or later it will be encountered, thus requiring keeper intervention to assist with shedding.

The method I use when a snake presents with dysecdysis follows that advocated by Weigel (2000). The snake is placed in a watertight container, not unlike the neonate tubs, and lukewarm water added to a depth just enough to submerge the snake's mid-body. It is then left to soak for 30-60 minutes. Sometimes further assistance is not required, as the snake will manage to shed itself while in the water. If this is not the case, the snake is pinned and then head-held using a two-fingered grip, while supporting its body with my remaining three digits in addition to my working surface. The other hand then uses a damp cotton swab, gently rubbed in an upward motion against the snake's upper labial scales and rostral scale. When the old skin has lifted, the cotton swab is rubbed in a downward direction over the lower labial scales and the mental scale. Once this manual shedding process is underway, the

keratinised layer should come away with minimal effort. If there is resistance, the skin has not softened or loosened enough. Care must be taken to ensure the shedding spectacles over the eyes lift with the rest of the skin, as a spectacle can sometimes be retained. It is also important to ensure that the shed skin includes that covering the caudal lure, as the lure is segmented and has a differently coloured soft spine. Retained sloughs on the slender caudal lure can dry and shrink, constricting blood supply to the lure, which can lead to necrosis. To ensure the skin has been successfully removed I always inspect the slough to make certain it is complete.

While an individual is in shed, I sometimes lightly mist the specimen with tepid water. However, I usually only do this with neonates or if the weather is particularly dry.

## ADULT SIZE AND SEXUAL DIMORPHISM

Female-biased sexual size dimorphism is typical of species of *Acanthophis*, with adult females having a mean adult SVL about 20% greater than males (Shine, 1980; Hagman *et al.*, 2008; Shine *et al.*, 2014). Shine *et al.* (2014) reported mean adult SVL for *A. wellsi* about 510 mm for males and 600 mm for females, although they did not provide data on size at maturity. Aplin and Donnellan (1999) did not identify any sexual size dimorphism, and the mean SVL for males (366 mm) and females (356 mm) were markedly lower than obtained by Shine *et al.* (2014). As the ranges of male and female SVL presented by Aplin and Donnellan (1999) included animals as small as 260 and 237 mm respectively, it is possible that the data for the latter authors included immature snakes.

In my collection, adult *A. wellsi* ( $n = 15$ ) had a mean SVL of 424 mm for males and 478 mm for females, with female mean 12.7% greater than male mean, a little less than reported by Shine *et al.* (2014) in terms of degree of sexual size dimorphism, although the means were noticeably smaller than reported by that study, but larger than reported by Aplin and Donnellan (1999).

*Acanthophis antarcticus* has been inferred to reach sexual maturity in the wild at around 24 months (males) and 42 months (females) (Shine, 1980), although I believe captive snakes can commonly reach adult size and, therefore, sexual maturity more quickly than their wild counterparts due to a presumably more reliable feeding frequency and the benefit the keeper has to consistently select a food source that they deem to be the optimum size for that particular snake at that point in its life. Sexual maturity in reptiles is generally related more to size rather than age (Johnston, 1987).

Sexual dimorphism is also apparent in relative tail length and shape. Male *A. antarcticus* have distinctly longer tails (relative to body size) with a slower taper from the cloaca due to the presence of hemipenes, whereas females exhibit a faster taper from the cloaca and a shorter tail length overall (Hay, 1972), and a general pattern of longer tails in males than in females at any given SVL occurs throughout the genus (Shine *et al.*, 2014). In at least *A. praelongus*, females also possess a shorter caudal lure but a longer terminal spine (relative to body size) than male conspecifics (Hagman *et al.*, 2008). I have observed a similar pattern of sexual dimorphism in tail length in *A. wellsi*, allowing sex to be determined on visual inspection, thus making probing redundant, although some sexually immature specimens can be challenging to visually sex accurately.

Aplin and Donnellan (1999) reported significant sexual dimorphism in number of undivided subcaudal scales (USC) in *A. wellsi*, with mean USC being 8.1 more in males than

females (pooled n = 43). For 15 adult snakes I maintained, mean male USC count was 25.4 (range 20-29) and mean female USC count 17.5 (13-21), in close agreement with the findings of the earlier study.

BREEDING

I report details of two breedings of this species during the season 2018/19. The first (pairing 1, or P1) was between one of the original males (M1) and the original female (F1), and the second (P2) representing a first-generation captive breeding between a male (M2, born 9 May 2013, one of a litter of 11 born to F1 resulting from a pairing with M1, of which 10 were the melanistic colour phase and 1 was the typical colour phase) and a female (F2, born 10 May 2014, one of a litter of 9 born to F1 resulting from a pairing with the other original male, all of which were melanistic) from two earlier litters involving the original pair. Neither M1 nor F2 had previously bred. All four individuals represented the melanistic form. Table 1 shows the mass, snout to vent length (SVL), total length and number of undivided subcaudal scales (USC) of the four parents just before being paired in December 2018.

M1 and F1 had been held in captivity since 2011 and had bred previously (M1 in 2013, and F1 in 2013 and 2014), so were clearly of mature size. M2 was in its sixth year and F2 in its fifth year in 2018, and M2 was of similar size to M1, a known mature snake. While F2 was noticeably smaller than F1 and could have had a little more condition on it, it was placed on an increased feeding regime following

Table 1. Basic parameters of the 2018/19 breeders (M1, F1, M2, F2).

Snake	Mass (g)	SVL (cm)	Total Length (cm)	USC (#)
M1	124.2	44.8	53.8	28
F1	195.5	54.2	62.0	13
M2	110.3	42.4	50.7	24
F2	107.0	43.6	49.0	21

mating; females typically continue to feed until the latter stages of pregnancy (Hoser, 1997).

F1 shed on 12 December 2018, after which M1 was introduced to her enclosure, but after some brief tongue flicking by the male, no interest was shown in copulation. This apathy towards mating persisted until, on 16 December, opacity was observed in the spectacles of M1 in addition to a generally dull appearance. M1 was removed and placed back in its own enclosure to slough. On 19 December, F1 was conspicuously swollen and displayed hypersensitivity to the touch, suggesting ovulation. M1 shed on 24 December and was returned to the tub with F1. On this occasion, tongue flicking immediately ensued. Upon locating the female, M1 mounted F2 and began caudo-cephalic twitching. The female was receptive, and copulation began within minutes. They were left together for the ensuing week, during which time mating was a regular occurrence. The duration of mating bouts typically appeared to last hours. Hoser (1983) has previously reported duration of copulation in *Acanthophis* species ranging from seconds to days. At the conclusion of the first week, the pair were separated for a week to regain their strength, retain their interest in mating, and digest their meal if they chose to eat. Thereafter, both specimens were offered food, with M1 declining and F2 feeding rapaciously. These feeding responses agreed with the observations of Hoser (1995) for *A. antarcticus*, with abstinence from feeding by males during breeding season, whereas females typically continue to eat until the latter stages of pregnancy. This rotational system (one week together/one week separate) was maintained until the end of the breeding season, with the copulation frequency never overtly waning. The pair were separated for the final time on 1 February 2019 when F1 showed signs of being in slough. F1 shed on 9 February, refused food for the first time in the season, showed significant swelling and weighed 223.6 g, all indicating gravidity. On 31 March, her mass was 250.5 g. This was a 28% increase in mass compared to that prior to first being paired.

F1 became noticeably restless, moving around its enclosure more often than usual, which is a common trait approaching parturition (Hoser, 1995). M1 resumed feeding on 9 February 2019 and weighed 116.5 g prior to this meal, a slight decrease from the pre-mating mass. It was placed on an increased feeding regime over the following few months and weighed 134.7 g on 1 June 2019.

M2 and F2 had their start of season sloughs on 23 December and 28 December 2018 respectively. M2 was introduced to the female's enclosure on 29 December, and immediately began vigorous tongue flicking and tracking the female. F2 was initially unresponsive and attempted to evade the advances of M2. It took several hours of persistence by M2 for mating to finally commence, after which copulations occurred throughout the first week. The same rotational system as P1 was employed, and at the end of the week, upon separation, both animals were offered food—M2 refused its first feed of the season, while F2 fed enthusiastically. Copulation frequency seemed to increase during their second week together, and the same feeding responses continued. F2 was observed in slough on 16 February 2019, coinciding with a scheduled week of separation, and M2 was removed. F2 shed on 24 February and weighed 143.5 g, which suggested gravidity. M2 was then re-introduced to take advantage of the newly shed female, as males are reported to be more aroused by freshly sloughed females (Hoser, 1987). Despite this, M2 was still frequently copulating prior to F2 shedding, albeit at a slightly lower frequency over the course of the most recent week. At the conclusion of the week, mating had been observed intermittently but, like their previous period together, with waning prevalence. On 1 March, the snakes were separated for the final time, and both were offered food. M2 ate for the first time since first being paired, and F2 also accepted food. M2 weighed 102.9 g prior to this feed and was subsequently placed on an increased feeding regime. On 24 March, F2 rejected food for the first time. F2 weighed 169.3 g on 20 April,



which was a 58% increase in overall body mass since the beginning of the breeding season. By this date, F2 had become markedly unsettled, suggesting parturition was approaching. M2 weighed 119.1 g on 1 June.

F1 gave birth to 12 neonates on 12 April, 62 days post slough, with 11 offspring being melanistic and 1 typically coloured. Immediately after birth, all progeny were placed in individual tubs, and the female's enclosure thoroughly cleaned and disinfected. Prior to being returned to her enclosure, F1 weighed 158.2 g. Since the pre-parturition weigh-in twelve days prior, approximately 36.9% of the maternal mass was due to the litter. A 19.1% overall loss in condition occurred since mating commenced.

F2 gave birth on 2 May (67 days post slough) to 5 neonates, all of which were the melanistic colour phase. Young were transferred and the female's enclosure cleaned like L1. Upon reintroduction to the enclosure, F2 weighed 120.3 g. According to the most recent pre-parturition

weigh-in, almost two weeks earlier, approximately 29% of its weight was due to the litter. This meant that F2 had an 11.1% overall increase in condition since being first paired due to its increased feeding regime.

For both litters, the timing of parturition was associated with a decrease in barometric pressure, F1 in the evening, with associated showers, and F2 in the early morning. Barometric sensitivity has previously been reported in *Acanthophis* taxa, associated both with parturition, and as an initiator of mating activity (Hoser, 1997).

GROWTH

Over the course of the first year, the mass and SVL of each neonate was recorded quarterly (Tables 2-5). For L1, mean mass gains were approximately 1.16 g per month while mean SVL gains were approximately 1.0 cm per month. In contrast, L2 individuals exhibited mean mass gains of approximately 0.70 g per month and mean SVL gains of 0.83 cm

Table 2. Litter 1 quarterly mass records (g): 0-12 months.

Snake #	12/04/2019	12/07/2019	12/10/2019	12/01/2020	12/04/2020
P1:1	4.30	5.46	7.27	12.43	16.11
P1:2	4.36	6.03	7.62	13.56	17.32
P1:3	4.40	4.69	6.77	11.91	15.38
P1:4	4.47	4.77	6.85	11.14	13.90
P1:5	4.19	6.30	8.37	13.79	18.75
P1:6	4.58	5.30	6.88	11.60	14.48
P1:7	4.75	7.17	10.99	21.85	32.38
P1:8	4.80	6.20	8.16	13.99	15.97
P1:9	4.65	6.14	7.70	14.45	17.60
P1:10	4.44	6.52	8.02	15.07	20.30
P1:11	4.45	5.58	7.99	14.23	19.90
Mean	4.49	5.83	7.87	14.00	18.37

per month. The disparity in the results between L1 and L2 is interesting as they were initially provided with the same diet, and L2 was transferred from adult mouse legs to pinkie mice, a larger and presumably more nutritious meal, approximately one month earlier (6 October 2019) than L1 (Figures 2-3). The growth rates for the two litters straddle the inferred growth rate of young wild *A. antarcticus* of approximately 0.9 cm per month (Shine, 1980).

### SEX RATIO WITHIN LITTERS

As yearlings, all animals from the two litters were visually sexed. L1 resulted in a M:F ratio of 7:4, while the gender split in L2 was 3:1. The predominance of males in both litters is consistent with my previous litters for this species, with 7:4 being the most even gender balance, and a male bias of 3:1 being the cumulative average. While Hoser (1997) states that sex ratio of captive-bred litters is approximately 1:1 in *A. antarcticus*, there are reports of primary sex ratios differing sub-

stantially from parity (Hay & Magnusson, 1986; Johnston, 1987).

### ACKNOWLEDGMENTS

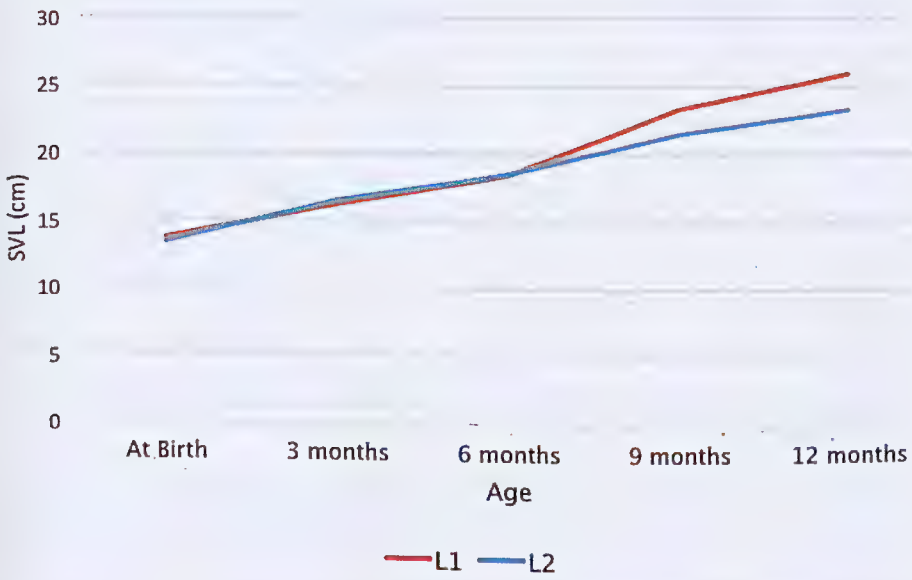
I thank Dave Mackintosh for supplying the original trio of wild-caught *A. wellsi*, and for sharing his herpetological knowledge through many enjoyable, thought-provoking conversations particularly on herpetofauna in the field. Dave's experience, knowledge and tracking skills, especially on wild populations of reptile, are eminently impressive. I also thank Rob McLeod, whose counsel I have often sought over the years regarding several aspects of reptilian husbandry. Rob's experience, knowledge and pragmatism in this realm are second to none.

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**Figure 2. L1 and L2 mean weight quarterly comparison (0-12 months).**



**Figure 3. L1 and L2 mean snout-vent length quarterly comparison (0-12 months).**



**Table 3. Litter 1 quarterly SVL records (cm): 0-12 months.**

Snake #	12/04/2019	12/07/2019	12/10/2019	12/01/2020	12/04/2020
P1:1	13.2	15.3	17.8	21.7	24.1
P1:2	13.5	16.0	18.3	23.2	25.5
P1:3	13.0	15.2	17.5	21.0	23.0
P1:4	13.8	15.2	17.2	20.6	22.8
P1:5	14.0	16.4	18.7	23.7	27.0
P1:6	13.5	16.4	17.6	21.7	24.0
P1:7	15.2	18.2	21.3	29.3	33.0
P1:8	13.8	16.3	17.9	23.4	25.1
P1:9	13.0	15.7	17.8	22.4	25.4
P1:10	13.1	16.4	18.4	24.3	26.6
P1:11	13.4	15.6	18.4	23.5	26.9
Mean	13.6	16.1	18.3	23.2	25.8



**Table 4. Litter 2 quarterly mass records (g): 0-12 months. \*P2:1 regurgitated and died on 14 May 2019.**

Snake #	02/05/2019	02/08/2019	02/11/2019	02/02/2020	02/05/2020
P2:1	3.01	N/A*	N/A*	N/A*	N/A*
P2:2	4.49	6.10	9.91	11.53	16.51
P2:3	4.51	5.42	6.57	8.87	10.20
P2:4	4.70	5.60	7.26	8.11	12.06
P2:5	4.41	6.12	7.85	10.92	13.04
Mean	4.22	5.81	7.90	9.86	12.95

**Table 5. Litter 2 quarterly SVL records (cm): 0-12 months. \*P2:1 regurgitated and died on 14 May 2019.**

Snake #	02/05/2019	02/08/2019	02/11/2019	02/02/2020	02/05/2020
P2:1	12.0	N/A*	N/A*	N/A*	N/A*
P2:2	14.4	16.9	19.9	23.2	25.8
P2:3	13.2	15.7	17.3	19.9	21.3
P2:4	13.3	16.1	17.5	19.8	21.7
P2:5	13.5	17.0	19.3	22.6	23.9
Mean	13.3	16.4	18.5	21.4	23.2

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# POSSIBLE PREDATION BY THE YELLOW-SPOTTED MONITOR (*VARANUS PANOPTES*) ON A BROWN SNAKE (*PSEUDONAJA* SP.)

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## INTRODUCTION

The Yellow-spotted monitor (*Varanus panoptes*) is widespread in tropical and sub-tropical Australia, ranging across the Kimberley of Western Australia, Northern Territory and Queensland (*V. p. panoptes*) as well as western Western Australia (*V. p. rubidus*) and New Guinea (*V. p. horni*) (Auliya & Koch, 2020). Its known diet consists of birds, small mammals, other lizards (including conspecifics), amphibians, eggs, and invertebrates (Shine, 1986; Rhind *et al.*, 2013; Cross *et al.*, 2020; Ward-Fear *et al.*, 2020). Despite this large dietary range, there are few published descriptions of actual predation events by this species. Interestingly, Dobson *et al.* (2024) recently described a single instance of an adult *V. p. panoptes* killing and consuming an adult Lesser Black Whip Snake (*Demansia vestigiata*). This species is also known to prey on larger elapids such as the mulga snake (*Pseudechis australis*) (Ward-Fear *et al.*, 2020) and multiple non-venomous snakes (Doody *et al.*, 2012).

## DESCRIPTION OF EVENT

On 12 March 2024, we observed an adult *V. p. panoptes* lying still by a temporary waterhole adjacent to a dirt road within Glenogra Station, Kynuna, Queensland at 1437 hours (Figure 1). At the time of the observation the sky was clear with an air temperature of ~35°C. As the authors approached slowly, LS noticed a small (likely juvenile) brown snake (*Pseudonaja* sp.) within touching distance of the monitor (Figure 1). The monitor appeared to be assessing the situation and eventually began to walk away from the scene, keeping

its eyes on the authors as it stopped ~10 m further. The monitor kept its head raised above the ground and subsequently reared on its hind legs, showing no signs of impaired mobility or physical discomfort.

Upon closer examination, it became apparent that the brown snake was injured, with two fresh wounds on its back and mud all over its body (Figure 2). Furthermore, the snake remained motionless except for weak tail writhing and tongue flicking as the authors moved to ~1 m distance from it. As the authors returned to the car and drove past the scene, they observed the monitor lying flat on the ground once more.

## DISCUSSION

Although Australian varanids are commonly thought to feed on snakes, published records of ophiophagy are scarce and consist mostly of gut content analyses rather than direct observations of predation events (Shine, 1986; Ward-Fear *et al.*, 2020; but see Dobson *et al.*, 2024). Based on geographic range and superficial physical features, the snake in question was either an Eastern (*Pseudonaja textilis*), or Speckled (*P. guttata*) Brown Snake (Emmott & Wilson, 2009; Mirtschin *et al.*, 2017), both of which are among the most venomous species in Australia. More specifically, the black flecks noticeable on several dorsal scales match the phenotype observed in specimens identified as *P. guttata* by LS in the same region, and the presence of 10 midbody scales from the ventrolateral surface to the midline of the dorsum hints at a total of 19 body scales as in *P. guttata*. However, conclusive identification



**Figure 1. Possible aftermath of a predatory interaction between *V. p. panoptes* and *Pseudonaja* sp.**



**Figure 2. Closer image of the brown snake after the monitor moved away. Two fresh wounds are visible mid-body, with mud smeared over the entire length of the snake.**



would have required close handling that the authors were not equipped for.

While the authors did not observe a predation event directly, the evidence strongly points towards a violent interaction between the Yellow-spotted monitor and the brown snake. The injuries on the snake's body were compatible with an attack from the monitor, which might have been deterred by the approaching car before it could finish its prey off (a behavior previously reported by Rhind *et al.*, 2013). This possibility is corroborated by the fact that the monitor did not run as the authors approached, but instead walked away slowly and stopped a short distance away. It is possible that it returned to feed on the snake after the authors resumed their drive off the property.

It is also possible that the brown snake was attacked and injured by another animal. The authors encountered Black Kites (*Milvus migrans*) in the area, and other snake predators such as feral cats are known to occur in the region. *Varanus panoptes* has been reported to scavenge for food (Blamires, 2004; Shannon, 2008), so it would not be surprising if this species also took advantage of prey that was incapacitated by other animals. Nevertheless, no other animals were visible in the immediate vicinity and the monitor was too close to the snake not to have noticed its presence (and vice versa).

Whatever the case, our observation supports the palatability of elapids to *V. p. panoptes* as prey items, in line with recent field- and lab-based reports (Dobson *et al.*, 2024; Chandrasekara *et al.*, 2024).

Interestingly, recent research has elucidated a pattern of widespread resistance to elapid venoms in varanids, including *V. panoptes* (Chandrasekara *et al.*, 2024; Jones *et al.*, 2021). This is likely an adaptation to enable targeting of elapids as prey and/or avoid being preyed upon by these snakes. However, this was only observed for neurotoxins (molecules affecting the nervous system) typical of Afro-Asian elapids and Australian death

adders (Chandrasekara *et al.*, 2024; Jones *et al.*, 2021; Youngman *et al.*, 2021) rather than for the coagulotoxins (i.e. blood-targeting molecules) commonly found in many Australian species whose diet is mostly mammal-based (Jackson *et al.*, 2016; Zdenek *et al.*, 2019).

Notably, the monitor showed no signs of envenomation, being fully mobile and even able to rear up on its hind legs. It is of course possible that the snake did not bite, yet in case it had, it is likely that the monitor's thick skin would provide protection against *Pseudonaja* bites due to the distinctly short fangs (~2 mm) typical of these snakes (Mirtschin *et al.*, 2017). However, Jackson *et al.* (2016) reported stark differences in venom phenotype between juvenile and adult *P. textilis* and *P. affinis*, with younger individuals lacking the signature coagulotoxins in favor of a heavily neurotoxic activity. This might facilitate predation of younger brown snakes by varanids that are at least partially resistant to certain neurotoxins. Further investigations into resistance to snake venom in varanids are therefore warranted. Overall, our observation calls for more research on trophic interactions between monitor lizards and snakes while reinforcing the importance of field-based natural history in animal ecology

## ACKNOWLEDGMENTS

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# MICROHABITAT SELECTION AND DENSITY IN A QUEENSLAND SKINK COMMUNITY

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## INTRODUCTION

The density of animals and the diversity of species at any one location is largely a function of the availability of microhabitats and the amount of food (Andrewartha & Birch, 1954; Pianka, 1989; Muñoz *et al.*, 2016). These two factors are usually a function of local geology, and climate, especially temperature and rainfall (Torr & Shine, 1993; Deichmann *et al.*, 2011). Species diversity, but not necessarily abundance of animals, increases with a decrease in latitude (i.e. tropical regions have more species due to a more or less seasonally equal climate), and to the diversity of microhabitats (Fisher, 1960; Vonesh, 2001).

One of the most diverse and abundant species group is, however, outside the tropics: the lungless salamanders, the Plethodontidae, that occur in the Appalachian Mountains of eastern United States of America. In some areas there may be dozens of species and up to 20,000 individual salamanders per hectare. Australia has no salamanders and so the smaller skinks occupy these "salamander habitats" (under logs, leaf litter, low shrubs, streamsides, etc.; Brattstrom, 1971; Greer, 1989). Here I describe a Queensland skink community that is diverse in species and abundant in individuals.

## STUDY SITE

The 32.4 ha study site is located on the west side of the Bruce Highway in Clemant State Forest between Rollingstone and Blue Waters, 60 km north of Townsville, Queensland, Australia. The site consists of Coastal Dry Sclerophyll Woodland Forest of *Acacia*, *Eucalyptus* (gums and iron barks) with an understory of shrubs and grasses. The area is fairly flat with rocks and large boulders at the northwestern

edge of the site and a few 1-4 m deep gullies traversing and draining west to east. A bare gravel quarry joins the southwestern part of the site. Based on November 2017 Google maps, that quarry has become larger in the 25 years since the surveys were carried out, but the rest of the site is not affected except by an access road from the highway to the quarry that has always been there. The area was burned about 10-50 years prior to the surveys, affecting the grasses and shrubs but not the trees. Half-buried rocks, logs, and leaf litter occur all around the site.

A small (ca 10 x 600 m) similar study site was on the east side of the highway. It had been burned annually for years to stimulate growth of introduced grasses for cattle (though after reaching about 0.5 m the cattle did not eat it due to sharp edges in the grass blades). This second site was burned November 3, 1993 during the study, so the site, besides a few *Eucalyptus*, had just ash (from burned grass, grass sprouts, or grass to 0.75 m after this date.

The area was cool during early visits and warmed as the season progressed. Rain occurred on Dec. 16, 1993. Grey Kangaroos, wallabies, rodents, cattle (n = 12) and horses (n = 5) wandered into the main study site from the extensive forest to the west. Kookaburras, Kestrels (both skink predators; O'Connor, 2003) and a variety of small birds occurred on the site. Treefrogs (*Litoria bicolor* and *L. rubella*) occurred after rains in a small depression. A variety of geckos and the agamid lizard *Diporiphora australis* were also observed on the site.

## METHODS

The study site was visited on four occasions: October 25, November 5, December 20 and

December 29, 1993. The width and length of the site was walked on each visit and the species present and their microhabitats noted. Seven 100 x 5 m or two 80 x 2 m (the latter on Dec. 20, 29) transects or strip censuses of lizards were done over a 10-30 minute period in the morning (0855-1045hrs, but on Oct. 25, 1150-1205hrs); strip censuses were made in various habitats. Three (censuses 6,8,9) were done at the same site as 1 and 5 (see Table 1).

Each time I left the main site, I walked back to my car through the smaller site on the east side of the highway looking for skinks. On November 5, immediately after the fire, I walked six 100 x 4 m transects at this site.

Skink taxonomy in Australia is in flux; names used in this paper are those given by Cogger (1992), the edition in use at the time of the study. However, some species identified in 1993 are likely to represent different taxa on more recent taxonomy. In particular, *Cryptoblepharus virgatus* in the Townsville area is now represented by three species, *Cr. virgatus*, *Cr. adamsi* and *Cr. pulcher*, which are difficult to distinguish on morphology alone (Horner, 2007). *Carlia pectoralis* was revised by Hoskin and Couper (2012), with the species at Clemant State Forest most likely to be *Ca. decora*, although *Ca. rubigo* has also been recorded nearby. *Carlia longipes*, following revision by Donnellan *et al.* (2009), should not be as far south as Clemant State Forest – it is possible that the species that I identified by that name is *Ca. schmeltzii*, a species reported to be common at Clemant State Forest by Kemp and Kutt (2004), but which I did not identify. Finally, *Concinnia tenuis* is a species complex in which the species present in the Townsville area are only distinguishable by scale counts, and hence my *Co. tenuis* is likely to be a composite of *Co. brachysoma*, *Co. sokosoma* and possibly *Co. tenuis* (Greer, 1992; Kemp & Kutt, 2004).

Skinks were occasionally captured (and released) to check identity. My success at capturing live skinks by hand was only about 15% successful, and especially low with leaf litter

skinks that ran into the leaves or into biting green ant nests. This often resulted in the lizard not being captured or at best capturing a piece of its tail. I invented the "skink scooper", a wastebasket or square pail (Brattstrom, 1996) to improve capture rates. When a leaf litter skink was sighted, the bucket was held 15-30 cm away from the skink. With the other hand, leaf litter and hopefully, the skink, were brushed quickly into the basket. The leaves were then removed carefully, leaving the skink at the bottom. This increased my capture rate of observed skinks to 95% and few specimens lost their tails.

## RESULTS

Eleven species of skinks occurred on the main site (Table 1). All eleven species were seen in October, while only six species were seen on the site in December. Skinks were most frequently seen in late October and early November (144,160, 180/ha in three transits), and rare in hot, humid December (0, 20, 100, 140/ha in four transits). The census data multiplied by the area of the site suggests that there may be as many as 14,256 skinks on this 32.4 ha plot.

Microhabitat observations (Table 1) show that the number of individuals and species on the site was influenced in part by seasonality (temperature and moisture; Brattstrom, 1965, 1971, 1999), but more important by microhabitat use. Some skinks were found mostly in gullies (*Ca. munda*, *Ca. storri*), some in big rocks (*Ca. rostralis*), others in the open and around small rocks (*Ca. jarnoldae*), though *Cryptoblepharus "virgatus"* also occurred in and under tree bark and *Ca. jarnoldae* also occurred in small crevices in rock and dirt. *Carlia "pectoralis"* and *Ctenotus robustus* occurred in the open, fairly cleared areas and the latter also occurred in bushes.

The skinks had several well-known defense mechanisms including inactivity, dropping their tails, and running into rocks, holes, crevices, bark, leaf litter, or green ant nests. *Carlia storri* would usually stay motionless using its cryptic, blending coloration to hide it.

**Table 1. Summary of skink activity and microhabitat, Queensland, Australia.**

Species	October	November	December	Microhabitat
<i>Carlia jarnoldae</i>	X		X	Small rocks, open
<i>Carlia "longipes"</i>	X	X	X	Leaf litter
<i>Carlia munda</i>	X	X	X	Gullies, open
<i>Carlia "pectoralis"</i>	X	X	X	Open
<i>Carlia rostralis</i>	X			Big rocks
<i>Carlia storri</i>	X	X	X	Sides of gullies
<i>Carlia vivax</i>	X			Open
<i>Concinnia "tenuis"</i>	X			Crevices, rocks, trees
<i>Cryptoblepharus "virgatus"</i>	X			Leaf litter, tree bark
<i>Ctenotus robustus</i>	X	X	X	Open, bushes, burrows
<i>Morethia taeniopleura</i>	X			Leaf litter

If disturbed it would drop from its gully-side location 1-2 m and then freeze again or run under leaf litter or small rocks.

While the study plot appeared to have been burned 10-50 years earlier, there appeared to be no negative impact on lizard diversity or abundance on the plot. In contrast, in the small study plot on the east side of the highway, which burned at least annually, only one individual skink (*Ca. munda*) was seen across in all trips and transits.

## DISCUSSION

The density of animals varies with the species, its behavior, the quality of the habitat (retreats, food, predators), and the season, especially the reproductive season (Andrewartha & Birch, 1954; Brattstrom, 1970, 1994; Heatwole & Stuart, 2008; Pianka, 1967, 1969, 1989). Most animals are fairly equally distributed throughout their preferred habitat and their numbers are sustained or raised if the habitat stays productive

as this study site seemed to be. Some populations become denser locally when there is a limited resource (food, mates, hiding places; Brattstrom, 1970, 1994; Neilson, 2002; Howard et al., 2003). Some populations are dense during the breeding season (Hoser, 2004) or because of the intrinsic nature of the species (i.e. schooling or aggregating fish, nereid worms). The high abundance of one species often means the lower abundance of a similar species (Summers, 2002). This is not the case if there is a diversity of microhabitats (Bruna et al., 1996; Melville & Swain, 1997). Different species occupy those different habitats (Brattstrom, 1999) thus either reducing competition for resources or utilizing different resources (niches; Lunney et al., 1989; Pianka, 1967, 1969, 1992). Seasonal and microhabitat diversification in this study shows how eleven species of skinks with a total population of over 14,000 individuals on a 32.4 ha plot (or 440 lizards per hectare), can live in one locality. This number is likely to be a minimum, as Kemp and Kutt



(2004), in a broader survey of the entire State Forest, also recorded several species of small skink that live deep in leaf litter (three species of *Lygisaurus*, and one *Pygmaeascincus*) that were not seen by me, likely due to their reduced surface activity. Competition is further reduced in this population by seasonal activity of individual species, their exploratory and escape behavior and presumably their food (Goodyear & Pianka, 2011; Greer & Jefferys, 2001). Similar high numbers of skinks and geckos (up to 67,000/ ha) have been reported (Akin, 1998; Rodda et al., 2001, 2005). This study shows that there may be more lizards in an area than expected and that repeated annual burning of an area is destructive to lizards, thus supporting the studies of Valentine and Schwarzkopf (2008) and Metcalfe and Peterson (2005).

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# FIRST RECORD OF *DIPORIPHORA WINNECKEI* (LUCAS & FROST, 1896) FROM NEW SOUTH WALES

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## INTRODUCTION

*Diporiphora winneckeii* is a small agamid species that occurs over much of the eastern arid zone of Australia. It is typically found on sand ridges dominated by hummock grass communities of Cane Grass (*Zygochloa paradoxa*) and Spinifex (*Triodia* spp.) (Downey & Dickman, 1993). *Diporiphora winneckeii* is insectivorous and diurnal, spending much of its time sheltering within vegetation (Van Der Reijden, 2014). Although considered to be common, it is not often observed due to its secretive nature and camouflage (Van Der Reijden, 2014).

*Diporiphora winneckeii* was previously considered to be distributed throughout the interior from central Queensland into Western Australia, but taxonomic revisions (Doughty *et al.*, 2012; Couper *et al.*, 2012) have split what was previously referred to as *D. winneckeii* into five species. The former western range of *D. winneckeii* is now occupied by the newly described *D. adductus*, *D. vesus* and *D. paraconvergens* (Doughty *et al.*, 2012), *D. ameliae* (Couper *et al.*, 2012) occupies the formerly presumed outlying central Queensland populations of *D. winneckeii* whilst nominate *D. winneckeii* is now restricted to the remaining eastern arid zone.

While being commonly recorded throughout the Simpson-Strzelecki Dunefields bioregion in South Australia, Northern Territory and Queensland (Melville & Wilson, 2019), there are currently no records of *D. winneckeii* from within New South Wales (Swan *et al.*, 2022). The lack of *D. winneckeii* records from within New South Wales is likely because the Simpson-Strzelecki Dunefields bioregion only fringes into the state's largely inaccessible north-western corner, with their preferred habitat of hummock grasses upon the crests

of sand ridges being highly limited within this area. Here I report the first record of *D. winneckeii* from New South Wales.

## OBSERVATION

On 3 October 2017 whilst opportunistically surveying sand ridges for wildlife along The Dunes Scenic Drive in Sturt National Park, NSW a single *D. winneckeii* (Figure 1) was observed sheltering amongst Lobed Spinifex (*Triodia basedowii*) (-29.004274, 141.023866). The individual was identified as a female *D. winneckeii* by two yellow stripes converging at the chest and pelvis on the ventral surface of the animal.

A further two individuals were observed basking upon Cane Grass (*Zygochloa paradoxa*) on sand ridges in South Australia within 30 kilometres of the New South Wales Border (-28.996018, 140.688518 and -28.986280, 140.838204 respectively).

## CONCLUSION

These observations confirm the presence of *D. winneckeii* within New South Wales and demonstrates that the species may be more abundant around the South Australia and New South Wales border than current records show. This brings the total number of agamid species recorded in New South Wales to 23 (Swan *et al.*, 2022; Chaplin *et al.*, 2023; Edwards & Hutchinson, 2023). This discovery gives credence to the notion that other arid zone species that have gone unnoticed in New South Wales may be recorded in the north-western corner of the state in the future. For example, *Pygopus nigriceps* has recently been confirmed as occurring in NSW from the same region (Madani, 2020).



**Figure 1.** *Diporiphora winneckeii* found sheltering amongst *Triodia basedowii* upon a sand ridge in Sturt National Park, NSW.



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# THE USE OF WATER AS A RETREAT FOR THE SAND GOANNA, *VARANUS GOULDII* IN NORTHERN NEW SOUTH WALES

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The Sand Goanna, *Varanus gouldii*, is widely distributed across most of mainland Australia except the south-east, western Cape York and adjacent Gulf country (Wilson & Swan, 2013). Much of this distribution is arid and semi-arid and *V. gouldii* is typically described as occupying dry habitats (Wilson & Swan, 2013). Several Australian varanids have been described as aquatic or semi-aquatic. Some, including *V. chlorostigma* (Dryden & Ziegler, 2004, as *V. indicus*), *V. mertensi* (Christian, 2004a), *V. mitchelli* (Shultz & Doody, 2004), and *V. semiremex* (Pianka, 2004), are tied to aquatic and semi-aquatic environments, while *V. panoptes* has also been reported to extensively use riverine or coastal habitats in parts of its distribution, including foraging for food underwater (Christian, 2004b; Martin, 1990; Shannon & Mendyk, 2009). In contrast, *V. gouldii* has rarely been reported to use water bodies, although Houston (1978) reported them being willing to enter temporary pools in desert areas during local flooding events, without providing additional details.

On 31 October 2011 at 12:35 hrs EST, while conducting a fauna survey on "The Oaks" via Yetman NSW (28°44'36"S, 150°44'22" E), a large monitor was observed from about 85 m, foraging approximately five metres from the far edge of a shallow seasonally dry pond approximately 11 x 9 m in an open area of derived low grasses and shrubs. As I approached the lizard to confirm identification it dashed towards me and into the pond with a splash. At this stage I was approximately 75 m away and it had ample opportunity to reach alternative cover amongst Buloke *Allocasuarina luehmannii* woodland with *Triodia scariosa yelarbonensis* understory approximately 30 m on the opposite

side of the pool from me. I approached the pool, and seeing no sign of the reptile concluded it was submerged beneath the water. Given the large size of the lizard, the proximity to the Qld border and the fact I had observed *Varanus panoptes* escaping into water at Coopers Creek, Windorah, Qld in 1987, I concluded there was a possibility that the observed animal could be *V. panoptes*. In order to check the identity of the lizard, I entered the water and located it after approximately five minutes by feeling with my feet. The lizard was immobile on a substrate of soft silt, leaves and sticks in approximately 30 cm of water, about four metres from where it had entered the pool. It did not immediately respond to being touched but on being removed from the water was revealed to be an adult *Varanus gouldii* with a total length of about 1.3 m.

The area where this lizard was observed is generally dry but subject to occasional flooding. No burrows were observed in the immediate area and the substrate was composed of hard compacted clays. While a commonly observed strategy for *V. gouldii* in this area is the cryptic pose adopted by many varanids (Greer, 1989), the capacity for use of a water body as a means of escape and concealment may be a reflection of the close relationship between *V. gouldii* and *V. panoptes* (Fitch *et al.*, 2006), or be a carry over from Australia's wetter past.

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**STONE GECKOS (*DIPLODACTYLUS VITTATUS* COMPLEX)  
IN NEW SOUTH WALES: NEW RECORDS OF *DIPLODACTYLUS FURCOSUS*  
AND AN UNUSUAL COLOUR VARIATION OF *DIPLODACTYLUS VITTATUS***

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The stone geckos of the *Diplodactylus vittatus* complex were revised by Hutchinson *et al.* (2009), who resurrected *Diplodactylus furcosus* from the synonymy of *D. vittatus* and described two new species, *D. calcicolus* and *D. wiru*. While genetically distinct and in some cases chromosomally distinct (Oliver *et al.*, 2007), the species in the complex differ in morphology largely in subtle features of coloration. Hutchinson *et al.* (2009) considered most records from New South Wales to belong to the widespread eastern Australian species *D. vittatus*, with *D. furcosus* only represented by two records from the far south-west of the state, near Wentworth, and one record from the north-west of the state.

During examination of the specimens of the complex in the Australian Museum (AM), I found additional records of *D. furcosus* in

south-western New South Wales that extend the distribution of the species, and three specimens of *Diplodactylus vittatus* from the Sydney region that show an unusual coloration not previously reported from this species, and that conflicts with the definition of *D. vittatus* provided by Hutchinson *et al.*

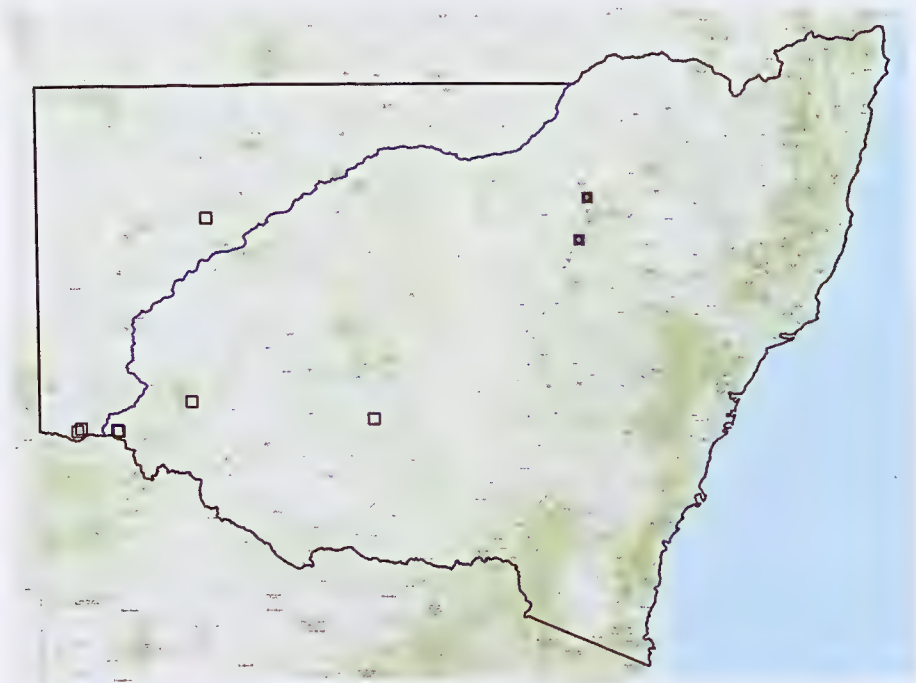
**Distribution of *Diplodactylus furcosus***

The two adjacent localities in south-western New South Wales mapped by Hutchinson *et al.* correspond to two specimens they list as examined, AM R156751 and AM R156755. These are two of four specimens of this species from these localities: R156751-52, Warranangra Stn, via Wentworth (34°01'31"S 141°35'43"E), collected 1 December 1999 and R156755-56, Moorna Stn, via Wentworth (34°03'31"S 141°33'06"E), collected 30 November 1999. Both of these localities are

**Figure 1. *Diplodactylus furcosus*, AM R160344, from Tapio Station, NSW.**



**Figure 2. Distribution of *Diplodactylus furcosus* in New South Wales. Open symbols represent *D. furcosus*, closed symbols represent the two eastern individuals that also show a rounded furcation of the dorsal stripe and that are tentatively considered *D. vittatus*. The Darling River is marked in blue.**



from west of the Darling River. There are three additional Australian Museum records from east of the Darling River: R125445, 85 km NW Balranald via Lake Pitapunga and Bidura roads (33°39'S 143°14'E), collected 3 April 1988, R150071, 10.5 km NE Dareton, ca 500 m W of Holland's Lake (34°03'16"S 142°08'02"E), collected 3 December 1996, and R160344, Tapio Stn (34°04'16"S 142°09'06"E), collected 23 March 2000 (Figure 1). The former two localities appear to correspond to records mapped by Hutchinson *et al.* (2009) and Swan *et al.* (2004) as *D. vittatus*. Other localities mapped in this region by these authors as *D. vittatus* are correctly identified, corresponding to the following specimens: R114481, 0.1 km W of Joului Gate, Mungo National Park (33°48'S

143°08'E); R 115218, 5 km NE Top Hut Homestead (33°38'S 142°58'E); R144957, Spring Track, Tarawi (33°25'09"S 141°07'56"E), and R147470, 1.2 km S Mallee Cliffs/Guthul Stn eastern boundary gate, Mallee Cliffs National Park (34°17'35"S 142°47'54"E). Swan *et al.* (2022) have transferred two of the above three *D. furcosus* localities from east of the Darling River that were mapped by Swan *et al.* (2004) as *D. vittatus*, along with a few additional records from west of the Darling River, but do not provide any explanation for the change. The Atlas of Living Australia (<https://bie.ala.org.au>, viewed 26 June 2024) has several localities for *D. furcosus* from the vicinity of Kerne Knob (33°24'S 142°06'E) and the Ginkgo Mineral Sands Mine (33°21'S 142°13'E) in the south-west of the state, but

**Figure 3. Stone geckos of uncertain identity from the north-western slopes of New South Wales: top: AM R14990a-b, Warrumbungle Range – one more typical of *D. vittatus*, the other showing some features of *D. furcosus*; bottom: AM R139266, Euligal State Forest, junction of Waterhole and Rocky Creek.**



these are not represented by voucher specimens to check the identities.

All seven of the *D. furcosus* specimens in the Australian Museum closely match the redefinition of that species provided by Hutchinson *et al.* (2009), particularly the tan to light brown ground colour, and the furcation of the pale vertebral stripe on the nape, extending to the eyes, with these markings narrowly dark-edged.

I can find no Australian Museum specimen of either *D. vittatus* or *D. furcosus* corresponding to the locality in north-western NSW indicated by Hutchinson *et al.* (2009). However, it likely represents a specimen in the South Australian Museum (SAM): R17930, 70 km N Wilcannia, collected 1979 (no further data). There is one additional specimen identified as *D. furcosus* in the SAM collection from New South Wales:

R12087, 22 mi. W Rankins Springs (33°56'S 145°55'E). I have examined SAM R17930, and confirm that it is *D. furcosus*, but have been unable to examine SAM R12087.

These additional records extend the distribution of *D. furcosus* well into western New South Wales, to the east of the Darling River (Figure 2).

Habitat data associated with the specimens of *D. furcosus* indicate a wide range of habitats used by the species: chenopod shrubland (R156751-52, R156755-56), belah woodland (R150071) and mallee/*Triodia* on a red sand ridge (R125445). All of these habitats are widespread in south-western New South Wales, and indicate that the distribution on *D. furcosus* in the state is not limited by habitat restriction.



Figure 4. Spotted colour pattern in *Diplodactylus vittatus* from the Sydney region. From top to bottom, AM R9006, R103690 and R106148.



In addition to these records, two individuals (AM R14990a, Warrumbungle Range; AM R139266, Euligal State Forest, junction of Waterhole and Rocky Creek, 30°41'S 149°08'E) from the Warrumbungles and Pilliga Scrub on the north-west slopes of the Great Dividing Range, sympatric with more typical *D. vittatus*, show some features of *D. furcosus*, with moderate definition of pale

extensions of the vertebral stripe obliquely towards the eyes. However, in these, the extensions of the dorsal stripe form a U-shape rather than the V-shape typical of *D. furcosus* (Figure 3). Further work is needed to determine whether these odd individuals represent further extension of the distribution of *D. furcosus*, aberrant *D. vittatus*, or an additional taxon in the complex.

## An unusual pattern variant of *Diplodactylus vittatus*

Hutchinson *et al.* (1990) described the vertebral stripe of *D. vittatus* as "most often continuous, relatively narrow and with a strongly scalloped margin; less often broken into a chain of angular vertebral blotches or continuous and straight-edged". Of the specimens of *D. vittatus* from New South Wales in the Australian Museum collection, almost all have a continuous pale vertebral stripe. However, three specimens, all from the Sydney region (R9006, Fairfield, registered 1926; R103690, 5 km SW Richmond (33°38'S 150°44'E), 3 Aug 1980; R106148, 8.0 km N Kingswood (33°41'06"S 150°42'54"E), 20 Sep 1981), have no trace of a vertebral stripe, but instead have rounded pale spots over the body dorsum (Figure 4). In other respects, these individuals are typical of *D. vittatus*. The first of these specimens was seen by Kluge (1967) and may have contributed to the 3% of NSW and ACT specimens he reported to have a "polyophthalmus" (i.e., spotted) color pattern. Kluge (1967) did not give a sample size for this percentage, but listed 89 NSW and ACT specimens of *D. vittatus* (a species which at the time included the taxa *D. calcicolus*, *D. furcosus*, *D. granariensis*, *D. ornatus*, *D. polyophthalmus* and *D. wiru*). However, only 49 of these were in the Australian Museum, with the other 40 specimens scattered across 14 other institutions, and hence his scoring of colour patterns may represent less than the potential full set of 89 specimens. With this uncertainty, the "polyophthalmus" or spotted pattern reported by Kluge (1967) for NSW/ACT *vittatus* is likely to be based on between one (if based only on Australian Museum samples) and three individuals (if based on all 89 specimens from NSW/ACT).

It is not clear whether this atypical colour pattern is restricted to the Sydney population of *D. vittatus*, or whether it represents a rare

variant across a wider part of the distribution. The Sydney/Wollongong coastal plain has contributed 40% of specimens of this species from NSW in the Australian Museum collection (91/236), with a frequency of 3.3% (3/91) of the spotted morph for this region compared to 0/145 for the rest of the state. This latter sample includes large subsamples from two localities: Round Hill Nature Reserve in the central west of the state, and the Moonbi Range on the New England Tableland ( $n = 16$  for each). This is suggestive that the spotted morph may be an occasional feature of the Sydney region populations.

## ACKNOWLEDGEMENTS

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# THE ORIGIN AND APPLICATION OF THE COMMON NAME "BANDY-BANDY" FOR THE ELAPID SNAKE *VERMICELLA ANNULATA*

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*Vermicella annulata* is one of the most distinctive species of Australian elapid snakes. The species was first reported in the literature by White (1790) as an illustration, but first named by Gray (1841), then transferred to the new genus *Vermicella* by Günther (1858), based on a Gray manuscript.

The earliest common name applied to the species that I can locate was Ring Snake (Anonymous, 1851). Although no scientific name was associated with this common name, the description of alternating black and white bands (Fig. 1) and nocturnal activity unequivocally links the name to this species. Shortly afterwards, the name Ringed Snake was associated with the donation of a specimen from Bathurst to the Australian Museum (Anonymous, 1855). Bennett (1863) and Krefft (1863) used the name Ringed *Vermicella*, then in 1869 coined the name Black and White Ringed Snake (Krefft, 1869). This, along with the previous variants, was used for several decades afterwards.

The first appearance of the common name

Bandy-Bandy, now universally applied to the species, appears to be a report of a snake found in a bed on Jones' Island on the Manning River (Anonymous, 1867). A second mention of the name appears in an 1879 report of the death of a four month old child bitten by a Bandy-Bandy, in a bed in a house at Cedar Party Creek, again along the Manning River (Anonymous, 1879a). No descriptive details are provided in either case to allow identification of the species, but both events involving a snake that has entered a bed do not suggest the semifossorial *Vermicella annulata* unless the mattress was on the floor.

Later that year, the name Bandy-Bandy is applied to a red and white snake found on a footpath at night in Lismore. The snake, when a kick was directed at it, was reported to have struck at the aggressor (Anonymous, 1879b). Both coloration and behaviour are not in accordance with *Vermicella*.

The next use of the name appears amid an exchange of letters published in the Australian Town and Country Journal between

**Figure. 1. *Vermicella annulata* from Inverell, NSW (Photo: G. Shea).**





1884 and 1885 (McCooley, 1884, 1885; Native, 1884; Lanigan, 1884; Coles, 1885a,b) and is much more informative.

McCooley (1884, as "M'Covey") first wrote, with respect to what is clearly *Vermicella annulata*:

"The species of snake I propose to refer to in this article is the ringed snake (*vermicella annulata* [sic]), which is a highly venomous and somewhat uncommon reptile, confined to particular parts of the colony and never found in the south. Neither can it be correctly stated that this species is found anywhere in the vicinity of New South Wales coast. It rarely or never attains a length of 30in; and, in comparison with its length, is peculiarly if not singularly slender. It is marked from tip to tip with alternate and latitudinal rings of pure white, the intermediate rings being of a bluish dark colour. One of the most remarkable peculiarities of this snake is that it always takes up its abode in large mounds of earth that have been deserted by ants, and it is not very unusual to find it in unoccupied ant beds. As many as a dozen may frequently be found together in such places; and, as these snakes seldom leave their habitations excepting in the three hottest months of the year, and seldom travel any distance from them, when they do leave it follows that at all times deserted or even occupied ant beds are the most likely places to find them. They are plentiful in the locality of Cowra, from which place about a year ago I forwarded a specimen to the trustees of the Australian Museum, which may now be seen in that institution. I have observed that this species of snake is not well represented in the Sydney Museum, for neither the specimen I contributed nor either of the other two in the same collection is a large or fairly representative one. Among dangerous snakes the ringed variety may be said to rank fourth, and is as deadly as the death adder - a snake, it may be mentioned, which is not nearly so venomous as popular error and popular superstition once supposed it to be. Taking into consideration the relative size of the ringed snake and the death adder, it may, with a fair amount of confidence, be assumed that the former is by far the more

venomous. The bite of a young snake of any other venomous species no thicker or larger than the ordinary-sized full-grown ringed snake would not be at all likely to bring about dangerous results, whereas the bite of a ringed snake of say 20in in length might be looked upon as most certainly liable to prove dangerous, if not fatal. Recent experiments with the ringed snake convince me that it is capable of killing an animal 70 times its own size in less than 40 minutes, and it is not unreasonable to assume that this snake, notwithstanding its smallness, is capable of killing any animal, so virulent is its poison. For a snake so small, the fangs and poison glands are remarkably developed; but this species is very timid, and we rarely hear of accidents from its bites. Some excellent specimens of this snake were seen in and near Cowra; but I was unable when there to persuade any of the owners to part with them; even a promise of immortal fame in the annals of the Australian Museum failed to "fetch" them. Any further information respecting this most interesting little snake-as to locality where found, size, manner and time of breeding, number at birth, &c., &c.,— would, I am sure, be most acceptable from your numerous correspondents. I should feel inclined to give a pretty handsome sum for a specimen of this snake (whether alive or dead) measuring anything over 30in."

The association of the species with ant mounds in the interior of New South Wales, while not specifically reported since (apart from occasional records from termite mounds; Wilson & Knowles, 1988), is plausible. The semifossorial *Vermicella* is active on the surface at night in hot weather after rain (Wilson & Knowles, 1988; Ehmann, 1992), and feeds on typhlopoid snakes (Shine, 1980), being able to follow their scent trails (Greenlees et al., 2005). Typhlopoid snakes in turn feed on ants, following the ant scent trails (Webb & Shine, 1992) and entering the ant nests to binge-feed on the larvae and pupae (Webb & Shine, 1993). The small size of the species (maximum reported snout-vent length for females, the larger sex 760 mm, with a mean female length of 544 mm; Shine,

1980; Keogh & Smith, 1996) and the reluctance to bite (Shine, 1980; Ehmann, 1992) are also in accordance with modern knowledge of the species, although the speculation on extreme venom toxicity is not.

In response to McCooley's claims, Native (1884) states:

"In your issue of June 14 appears an article under the above heading in which the writer attempts to describe the ringed snake, and in doing so he made quite an army of errors both as to size, locality, where formed, its abode, &c. Thinking perhaps that a good many of your readers might be led astray by such remarks and treat this very venomous reptile as being merely seen perhaps only during the three hottest months of the year, and again that it is harmless and timid, I think that a few facts concerning this reptile may be both interesting and useful; at least they are correct.

First, your correspondent says it cannot be stated that the snake is found on the New South Wales coast, and that it rarely ever attains a length of 30 inches; that it always takes up its abode in ant hills or mounds of earth; but the most strange part of his description is when he says that they very seldom leave their habitation except during the three hottest months of the year.

The Richmond River, which I hope Mr. McCooley will not dispute is on the N.S.W. coast, as is also the Clarence River - well, in both those districts this snake is found. On the Richmond specimens are numerous. I have seen them on the Clarence at Grafton, but not many, and have known them to be killed amongst the vines and flowers around houses there. On the Richmond it is a common occurrence to go into a house and see one of these black and white beauties preserved in bottles. They look very nice. The blacks are very frightened of this snake, and in fact will not even kill the reptiles. They inhabit chiefly the sandy plains or heath and the river frontages, and are most dreaded during the warm summer nights while they are lying or crawling about. Those who have been to a semi-tropical climate as the Richmond is [sic] must know that the summer there means

nearly nine months of the year, and that during that period it is worth any person's while to keep his eyes open when travelling, especially at night. I have never yet heard nor seen any one who thought these snakes inhabit ant hills, though I know quite well, and have proved beyond doubt, that the blacksnake takes up his abode there during the winter months. The ring snake is anything but timid, and will not move out of your way, and is consequently more dangerous, even in this respect, as compared with other snakes. I have seen them from 1ft to 3ft 6in long. I am speaking of the ringed snake. Mr. Sohn, storekeeper on the Richmond, showed me several of them, and also said it was no novelty at all to forward them to the Museum, Sydney, as they were constantly being sent there from the country. This snake is known as the "Bandi Bandi," of which there are two species, the one described by your correspondent, and the other is almost similar, but instead of having pure white rings they are of cream colour; the dark rings are a dark brown. This latter snake is regarded as a deadly enemy. As to time of breeding and number at birth I cannot say, but fail to see why they should differ in this respect from other species of snake. I believe this snake is also found on the Tweed River, but cannot speak as to the truth, I not having seen any there."

The combination of size, brown body with cream rings, and the behaviour and habitat for the larger of the two species reported in the Northern Rivers area only fits Stephens' Banded Snake (*Hoplocephalus stephensii*) (Fig. 2), which is considered dangerously venomous.

Two more reports indicate that the name is derived from indigenous languages from the north coast of New South Wales. Cohen (1890) notes the name (as "Banda Banda") was used for the Ringed Snake by two indigenous men from the Hastings River area in his employ, while Waite (1898), although continuing to use Ringed Snake as the preferred common name notes that "on the Macleay River, it is known as Bunda Bunda, a native name". It is probably Waite's mention of the name in a widely available book that led to the next book on Australian reptiles, by King-

**Figure 2. *Hoplocephalus stephensii* from Mt Tambourine, south-east Queensland (Photo: Scott Eipper).**



horn (1929), using Bandy-Bandy as the common name for the species, and subsequent field and reference guides have maintained this usage (Worrell, 1963; Cogger, 1975; Wilson & Knowles, 1988; Ehmann, 1992; Wilson & Swan, 2003).

The original use of the name Bandy-Bandy for *Hoplocephalus stephensii* is explicitly confirmed by Campbell (1892) who, writing about the Big Scrub area between Lismore and Byron Bay, provides a description of what is undoubtedly that species ("There was an exceedingly beautiful little snake we captured in the scrub. It was nearly 3ft. long, although I believe the usual length is only about 2ft. It was striped alternately black and silvery grey. The markings were across the body from side to side, while the underneath parts were greyish white. It was very plucky, and as soon as it saw us it faced us with jet-black shining eyes, and prepared for action by flattening its head and withdrawing its neck in the form of the letter S, ready to strike. In herpetology the snake is named *Hoplocephalus Stephensii* [sic], and is found in the coast district of New South Wales north of Sydney.") but then states "the locals use the aboriginal name of "bandi-bandi" for Stephens's snake. It is a rather strange coincidence that the natives' name for a banded snake should be "bandi-bandi".

The bandi-bandi is a night prowler, and often, I am informed, its white rings may be seen shining under moonlight on tracks, especially in stony localities."

Occasional subsequent stories in the newspapers, always associated with the north coast of NSW, treat the name Bandi-Bandi as referring to one of two species, the larger one with less glossy scales and less contrasting bands, while the smaller one, when described, carries the description appropriate for *Vermicella annulata* (Anonymous, 1918; Gillies, 1931; Manewell, 1931; Blue Gum, 1933).

While it is evident that the name Bandy-Bandy was historically used, at least in part, for *Hoplocephalus stephensii*, it is curious that the most distinctive feature of the behaviour of *Vermicella annulata*, its tendency to raise loops of the body off the ground, is never mentioned in these early accounts, even when the account clearly refers to *Vermicella*. This behaviour seems to have first been noted by Longman (1948), and then by Cogger (1960), Mertens (1960), Worrell (1963), and with a more detailed description by Bustard (1969).

While the name Bandy-Bandy has been attributed to indigenous languages, which one is it from? There are six languages in the region covered, the north coast of NSW. From



south to north, these the Gathang, Dhang-gati, Gumbaynggirr, Yaygirr, Bundjalung and Yugambah languages, and vocabularies are available for all (Lissarrague, 2007, 2010; Morelli, 2012, 2015; Sharpe, 2013). Only Gathang, a language from the region between the Wilson River, Gloucester and Port Stephens, uses the word "bandibandi" (Lissarrague, 2010), which is attributed to the "Ring Snake", noting the transfer of this word into English vocabulary. In Yaygirr, the name Algalaga has been reported for the Bandy-Bandy (Morelli, 2012), in Gumbaynggirr, the names used are Wagabirrul and Barrigidiling (Morelli, 2015), and in Bundjalung and Yugambah, the names used are Dalil and Gambahn (Sharpe, 2013). No specific term for *Hoplocephalus stephensii* is provided in any of these lexicons, and it is possible that none distinguish between *Hoplocephalus stephensii* and *Vermicella annulata*.

Thus, Bandy-Bandy joins several other common names for Australian snakes in wide use that are derived from indigenous languages: Woma for *Aspidites ramsayi*, Nawaran for *Nyctophilopython oenpelliensis*; Bardick for *Echiopsis curta*, Taipan for *Oxyuranus scutellatus*, Norne for Western Australian populations of *Notechis scutatus*, Dugite and Kabarda for *Pseudonaja affinis* and Gwardar for *Pseudonaja mengdeni* (Gray & Neill, 1845; Moore, 1884; Waite, 1917; Thomson, 1933; Bedford, 2024).

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## BOOK REVIEW: REPTILES OF VICTORIA: A GUIDE TO IDENTIFICATION AND ECOLOGY.

By Peter Robertson and A. John Coventry, 2019.

viii + 323 pp., 456 colour photographs.

Published by CSIRO Publishing, Clayton South, Victoria.

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As the described herpetological diversity of Australia has increased over the past half-century, an initial emphasis on Australia-wide field guides has gradually become replaced by a trend to more local, compact and portable field guides. At the state and Territory level, we have had field guides to the reptiles of Western Australia (Storr *et al.*, 1983, 1990, 1999, 2002), Queensland (Wilson, 2015), New South Wales (Swan *et al.*, 2017), the ACT (Bennett, 1997) and Tasmania (Hutchinson *et al.*, 2001). Finally, we now have a state-wide field guide to Victoria's reptiles, following several years after a smaller volume was produced on the snakes by the same authors (Coventry & Robertson, 1991).

Despite being the smallest of the mainland states, and with a fauna of just 116 species (plus a few species that are vagrants to Victorian waters or that have established feral populations), this works to the advantage of this book. Only two of these species are restricted to Victoria (the skink *Pseudemoia cryodroma* and the agamid *Tympanocryptis*

*pinguicolla*), making the species accounts also relevant to those outside the state. Further, the species accounts can cover much more than just identification while still creating a compact volume. The authors have taken full advantage of this space, providing for each species multiple photographs showing a range of variation and details of important features, descriptions, comparisons to similar species, a detailed map (using a grid-square approach to occurrence, with each square representing a 10 x 10 minute block, or at Victoria's latitudes, about 15 x 18 km), recent synonymic combinations (a handy feature, given the number of taxonomic changes to the fauna in recent decades), habitat preferences, discussion of the conservation status and, most importantly and as indicated by the title, lengthy accounts of the natural history of each species. The level of detail on the biology of each species is unique among the state-based guides, including activity patterns, behaviour, diet and reproductive details, many of them not previously



published and based on the authors' long experience with these species in the wild.

The book opens with a brief general chapter on Biology of Reptiles, followed by a lengthier 20 page chapter on the biogeography of Victorian reptiles and the distribution of the major habitat types (again using the 10 x 10 minute grid used by the Victorian Biodiversity Atlas), a brief (3 page) overview of classification and nomenclature, and a list of the fauna, keyed to the species account pages. A hierarchy of dichotomous keys to orders, families, genera and species (the latter including subspecies) is scattered through the book, many illustrated with labelled line drawings or photographs of key character states. In conjunction with the photographs, comparisons with similar species and distribution maps, these should provide rapid and accurate identifications for any species.

The accounts of species and subspecies known from the state are followed by a shorter list of species that may occur in the state, with unconfirmed records or distributions that about on the border regions, or feral species that may occasionally be transported to Victoria.

There are short sections on snake bite treatment and Victorian wildlife legislation, a glossary of three pages, and an extensive (15 page) Selected Bibliography. The indices are detailed, and include synonymous combinations, so no matter whether you seek a blind snake under the genus *Anilius*, *Ramphotyphlops* or *Typhlina*, it will take you to the correct account.

This book has been a very long time coming. I can recall John Coventry talking about working on it with Peter Robertson in the late 1980s (with the 1991 snake guide being a trial run), and with John's retirement from the Museum of Victoria in 2002, he aimed to spend more time on it. With John's death in 2007, the task of completing it has fallen on Peter's shoulders alone. However, that extremely long gestation has allowed the authors to continue to refine and add to the

book as more knowledge has become available. In addition to his work on the text, Peter Robertson has contributed most of the photographs.

The long gestation has also resulted in the addition of species to the Victorian fauna, as people survey the border regions and taxonomic work continues. *Denisonia devisi* was first recorded in 2005, and revisionary work on *Ctenotus* in 1999, *Hemiergis* in 2011, *Liopholis* in 2002 and *Pseudemoia* between 1988 and 1992 have added seven species to the fauna: *Ctenotus olympicus*, *Hemiergis talbingoensis*, *Liopholis guthega*, *L. montana*, *Pseudemoia orocryptus*, *P. pagenstecheri* and *P. rawlinsoni*.

Sadly, modern surveys have continued to fail to locate two snake species that were last seen in the 1860s, *Oxyuranus microlepidotus* and *Acanthophis antarcticus*, and these species are likely to be extinct in the state (although there remains a slight possibility that Death Adders may yet be found in the extreme north-east corner, as they remain present only a short distance to the north in NSW).

The authors have adopted the preliminary findings of Rabosky *et al.* (2014), resulting in the submerging of *Ctenotus brachyonyx* into an expanded *C. inornatus* and *C. robustus* into an expanded *C. spaldingi*, two name changes that have yet to receive widespread acceptance. Hence, readers of this book trying to cross-reference to other sources, where neither *C. inornatus* nor *C. spaldingi* are reported to occur anywhere near southern Australia, may become confused. However, the changes are explained in the text, and the index will still lead to the taxon under either name.

In the absence of genetic sampling of Victorian populations of the gecko genus *Rhynchoedura* by Pepper *et al.* (2011), the species identity of Victorian populations remains uncertain as the species recognised by Pepper *et al.* were mostly distinguished on genetic criteria. Robertson and Coventry argue that

the species present in the state is likely to be either *R. angusta* or *R. ormsbyi*. A similar sampling defect by Reeder and Reichert (2011) for western Victorian *Hemiergis* led to uncertainty about the specific identity of those populations. However, in this case, Coventry had been working on the morphology of the *H. decresiensis* complex prior to his retirement, and the authors have recognised the western Victorian populations as *H. decresiensis* rather than *H. talbingoensis*.

The reader will also discover information on the translocation and spread of several species into the Melbourne area: the turtles *Chelodina expansa*, *Chelodina longicollis* and *Emydura macquarii*, the gecko *Christinus marmoratus*, and the dragon *Intellagama lesueurii* (both subspecies, which now apparently hybridise along the Yarra River).

I found very few errors, and most of those were typographic. The only significant error I noticed was the diagnosis for *Egernia* (p. 127) incorrectly stating that the parietal scales were in contact behind the interparietal – the correct character state is given in the key (p. 99).

In summary, this book is an excellent reference work on the Victorian reptile fauna and will be of interest to naturalists and researchers, not just those in Victoria, who are seeking information on the species that occur in Victoria as well as more widely.

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Juvenile *Acanthophis wellsi* from 21°53.655'S 117°30.569'E, Pilbara, Western Australia (Photo: M. Peterson). See paper on husbandry and captive breeding of this species on p. 73.



*Egernia kingii* from Greenhead, Western Australia (Photo: M. Peterson). See paper on diet of this species on p. 54.